SUPPLEMENT
TO THE
JOURNAL OF GAS LIGHTING,
WATER SUPPLY, & SANITARY IMPROVEMENT.

VOL. XXXV. LONDON, JUNE 22, 1880. No. 893.

BRITISH ASSOCIATION OF GAS MANAGERS.

SEVENTEENTH ANNUAL MEETING.

PAPERS READ.

(II.)

ON TESTING CANNEL AND COAL.

By Mr. HARRISON VEEVERS, of Dukinfield.

Eight years ago Mr. Paterson, the Engineer of the Warrington Gas-Works, and Past-President of this Association, treated the members to a paper "On the Lithology of Gas Coals," pointing out the characteristics of various coals, and giving tables of several analyses which he had made. He did not, however, describe any method of testing for quantity and quality. This paper is intended, to a certain extent, to be a sequel to that essay, and will in the first place describe a simple apparatus for use in small works where the cost of elaborate plant cannot be afforded, and where appeals to an analytical chemist would, for a similar reason, be prohibitory. In the second place, a few notes will be given on scientific testing.

A manager who purchases a cannel or a coal on the recommendation of a testimonial from a professed analyst, finds himself occasionally with inferior results when the bulk is used in the works. The writer recalls a case where a coal was tested by a reliable authority from a sample sent by a colliery proprietor, and a testimonial given that it had yielded over 10,700 feet per ton of 18-candle gas, fairly free from sulphur. The coal when delivered in bulk was not even worth its cost of cartage; it was grossly charged with sulphur, glistening with pyrites, and white with salts of lime. Fortunately no contract had been entered into, and the supply was stopped. This is a sample case of what has occurred in the experience of most gas engineers. The fault rests not with the analyst in such cases, but with the proprietor or agent who supplies samples superior to bulk. Reference will be made presently to the necessity for proper sampling.

In a small works and for ordinary use, where the illuminating power and yield of gas per ton are the main considerations, the following apparatus will be found inexpensive and efficient:—On the top of one of the ascension-pipes from a retort in use in the works are fixed two 4-inch valves—one to allow the gas to pass into the hydraulic main, and the other into the experimental apparatus. This consists of a 4-inch connection-pipe, a receptacle for tar and ammoniacal liquor, a condenser (consisting of a series of 4-inch street main-pipes), a purifier 6 feet square (which may be procured second-hand), an 80-light wet meter, a Kirkham and Sugg's improved jet photometer, a thermometer, and a 4-inch pipe (with valve) to conduct the gas into the main-pipe of the works between the hydraulic and the exhauster.

It will be observed that no mention is made of a holder and tank. It is their absence which causes this method of testing to be so economical in the cost of apparatus, and the author contends that the results arrived at are as reliable comparatively one coal with another, and with the practical results given when the bulk is operated upon, as though a holder had been provided.

When it is required to make a test, the valve to the hydraulic is closed, and that to the apparatus is opened. The stoker then charges the retort with exactly one-tenth of a ton of the material to be tested. The indications of the meter and photometer are taken every quarter of an hour for six hours, then the retort is discharged, the coke extracted, slaked with as little water as possible, and weighed. The quantities of gas, of tar, and of liquor are ascertained and multiplied by 10, so as to give the rates per ton. The illuminating power is ascertained by multiplying the average of each hour by the number of feet made in that hour; these added together and divided by the total number of feet made in the six hours gives the illuminating power. A specimen page of the book for entering the observations is given in this paper, and will illustrate the method of procedure. (See Table No. 2 appended.)

The following important facts will be ascertained:—1. The yield of gas per ton, in feet. 2. The illuminating power. 3. The quantity of coke and its appearance. 4. The amount of tar and ammoniacal liquor. 5. The length of time the material should be carbonized. Of course other information could be ascertained, such as the amount of sulphur, the specific gravity, &c.; but as the object of the tests was primarily to ascertain the quantity and quality of gas from the sample, these matters were not considered.

Of the above, the fifth—that is, the length of time the material should be carbonized—is very instructive. It is a matter of much greater importance than is generally considered, and attention was very properly drawn to it by Mr. William Carr in his Inaugural Presidential Address to the members of the Manchester District Institution of Gas Engineers on the 28th of February last. In Table No. 1, accompanying this paper, are many instructive cases where a cannel or a coal has given off the whole of its gas before the end of the fifth hour, whilst in one case 950 feet, in another 960, and in another 1020 feet were made in the sixth hour. The loss to stock by not recharging at the end of the fourth or fifth hour may be very readily calculated. In the cases Nos. 1 and 2 in Table No. 1, experiments were made on two similar samples of cannel—the first at an ordinary temperature, the second with a keener heat. In the case of No. 2, only 50 feet per ton of non-illuminating gas were added to stock during two hours; whereas had the charge been only a four-hour one, 8050 feet per ton of 26-candle gas would have been added to the gasholder stock, at the same cost of fuel, labour, interest, and wear and tear. By the increase in temperature in the furnaces, it will be observed that No. 2 yielded 700 feet per ton of 3-candle better gas than No. 1. An inspection of the table will convince a practical man of the importance of high heats and short-time charges, and that thereby the gain to revenue will far exceed the cost of renewals of retorts.

An interesting subject in the method of testing as above described is not only that the quantities of gas given off hourly vary, but also the illuminating powers. It is almost invariably the case that the greatest light power is yielded by the gas expelled at the end of the first hour and during the second one. Frequently the gas given off in the sixth hour is so poor in quality that the photometer cannot indicate the value, although the amount of gas generated may be over the rate of 1000 feet per ton.

In Table No. 1 the results of tests for quantity and quality by other operators are given to show the practical value of the author's method of testing. It will be observed that the author has not attempted to enter into the more elaborate and scientific methods of analyzing samples of coal, coke, and gas, as it requires a more technical education, and a greater

TABLE No. 1.—RESULTS OF TESTING CANNELS AND GAS COALS.

MATERIALS TESTED.	First Hour.		Second Hour.		Third Hour.		Fourth Hour.		Fifth Hour.		Sixth Hour.		Total Quantity.	Average Quality.	Weight of Coke per Ton.	Thermometer at Meter.	Mr. Collins's Tests.		Mr. Paterson's Tests.		Mr. Graham's Tests.		Mr. Tootill's Tests.	
	Quantity.	Quality.	Quantity.	Quality.	Quantity.	Quality.	Quantity.	Quality.	Quantity.	Quality.	Quantity.	Quality.												
													Feet.	Candles.	Cwt. q. lbs.	Degrees.	Feet.	Cndls.	Feet.	Cndls.	Feet.	Cndls.	Feet.	Cndls.
Cannels.																								
1. Wigan Coal and Iron Company (Curly)	2270	10¾	2300	28¼	2620	23¼	2330	17⅝	1610	11	410	9⅝	11540	18¾	14 2 6	—	—	—	12600	27½	—	—	11174	21
2. Do. do. do. do.	4010	27	4040	25	3180	15½	1020	9	50	0	0	0	12250	21¾	12 2 0	52 to 55								
3. Rose Bridge Colliery	2500	17	2300	30	2300	26¼	2200	21½	1400	13¾	550	10¼	11250	21½	13 1 16	—	—	—	11125	22½	—	—	10537	24
4. Bridgewater Trustees	2220	12½	2280	24	2320	19⅛	1930	16	1550	8¼	590	10½	10900	16¼	11 1 0	—								
5. Do. do.	2000	12⅝	2200	28	2300	22½	1950	17	1450	13½	530	10¼	10630	20	13 0 24	—								
6. Do. do.	3300	19	3780	20⅝	2950	13½	850	8¼	80	0	0	0	10910	17¼	13 3 0	52	10241	20	—	—	9676	20⅓	9551	19¾
7. Do. do.	3190	21	3320	22½	3190	16	1430	10	80	0	0	0	11210	18½	14 0 12	53								
8. Do. do.	3050	14	3090	22	2880	16	1940	11	840	9	80	8	11880	15⅝	12 3 2	62								
9. Do. do.	2440	11	2820	24⅓	2880	19⅛	1900	14¼	520	10½	50	9	10610	17¼	14 1 24	65								
10. Do. do. (best lumps)	2230	13	2530	24	2830	20	2200	16	1030	12	320	8	11140	17½	13 3 0	64 to 67	—	—	—	—	—	—	—	—
11. Moss Hall Company (picked)	3040	19¾	2900	30⅜	2950	29	2550	27	1200	22	760	17	13400	25¼	11 0 8	—	—	—	—	—	—	—	—	—
12. Do. do. (mixed)	2400	14¼	2300	29⅝	2400	27¼	2200	23¼	1700	19½	960	16	11960	22½	12 3 22	—	—	—	—	—	—	—	—	—
13. Ellerbeck (with coal)	2990	16½	3380	20⅛	3070	13⅛	1260	8	90	7	0	0	10790	16	13 2 8	65	—	—	—	—	—	—	—	—
14. Roscow and Lords (mixed)	2250	16	2680	25	2390	18	1520	14	660	10	80	9	9580	18¼	15 2 24	64								
15. Do. do. (picked)	2810	16	3010	24	3100	20	2190	13	500	9	140	8	11750	18	13 2 8	66	—	—	11850	16	—	—	9916	18½
16. Do. do. (mixed)	2540	18½	2600	21¼	2410	18	1690	13¼	620	9	90	0	9950	18¼	14 1 14	65 to 67								
17. Scowcroft's Rose Hill, Bolton	2100	11	2440	23⅜	2470	19¼	1890	15	1030	10⅜	360	9¼	10290	17¼	14 2 26	64 to 66	10325	16¼	—	—	—	—	—	—
18. Chatterley Iron Company	2520	21½	3450	30	2860	25½	1980	20	990	11	340	7⅜	12050	23½	Coke useless 13 3 20	—	—	—	16400	17½	12000	15¼	—	—
19. Plaskynaston	2810	22½	2710	29¾	2380	22½	1800	21¾	740	8¼	180	8¼	10610	23	14 0 12	—	—	—	—	—	—	—	—	—
Gas Coals.																								
20. Wigan Coal and Iron Company (Arley)	2100	9¼	2200	24	2200	18½	1980	13½	1550	11	830	9½	10760	15	14 2 16	—	9783	18¼	11840	15⅓	10060	17¼	—	—
21. Rose Bridge Colliery (Arley)	2800	17½	3160	18½	2930	11	1480	9	16	9	0	0	10530	14½	15 1 2	51								
22. Do. do. do.	2710	18½	2530	21	2590	16	2000	12	810	9⅛	200	0	10840	15	14 2 16	57	9783	18¼	12600	15½	—	—	11511	12½
23. Do. do. do.	2360	17	2910	20	2800	13⅛	1940	10	560	8	40	0	10610	14⅛	15 2 24	53 to 56								
24. Moss Hall Company's do.	1910	11	2030	24⅞	2180	19½	2020	15	1500	11	950	9¼	10590	15	13 3 20	—	—	—	10800	16¾	—	—	—	—
25. Do. do. do.	1700	10	2050	26¼	2350	21⅛	2300	15	1500	10⅜	550	8¼	10450	16½	13 3 0	—								
26. Blainscough Hall Company (Arley)	2560	10½	2230	17	2100	13½	1900	11	1560	10½	550	7⅜	10900	11⅛	11 3 4	—								
27. Do. do. do. unscreened do.	1470	8¼	1800	17¼	2050	16	2080	11	1720	9	820	8	9940	12¼	14 1 24	—	—	—	11970	16½	—	—	—	—
28. Do. do. do. screened do.	1350	10	2500	22	2600	14½	2550	11¼	1450	9	220	7½	10670	14	15 0 10	—								
29. Seddon and Son, Westhoughton (Arley)	2260	11	2900	21½	2950	14	2300	10¼	540	9	30	8¼	10980	12¾	15 0 0	—	—	—	—	—	—	—	—	—
30. Do. do. do. do.	2200	10¾	2250	21½	2300	16	2100	10⅜	1500	9	210	8½	10560	14¾	14 1 14	—	—	—	—	—	—	—	—	—
31. Do. do. do. do.	3440	17½	3360	14	2650	10	1420	8	240	0	0	0	11110	13	14 3 18	50 to 54	—	—	—	—	—	—	—	—
32. Do. do. do. do.	2300	15	2750	20¼	2940	12	1780	8	270	0	10	0	10050	14¼	14 0 12	53 and 54	—	—	—	—	—	—	—	—
33. Hilton House Colliery	1180	7½	1800	18	2000	17	1850	12½	1650	10¼	1020	8	9500	11	15 2 24	—	10068	15	—	—	—	—	—	—
34. Ellerbeck	2410	13¾	2500	21⅜	2340	16⅜	1650	12¼	600	9	150	0	9650	17	13 3 20	57 and 58	9618	16½	12100	15	—	—	—	—
35. Do.	2770	17	2720	20	2480	15½	1580	11½	620	9	170	0	10340	15⅜	14 1 24	59 to 61								
36. Fletcher, Burrows, and Co. (Arley)	1740	14	2040	26	2350	21⅛	2300	14	1500	9½	630	7¾	10560	17	13 0 14	—	—	—	—	—	—	—	—	—
37. Hulton (Arley)	3220	18½	2850	17¾	2360	13½	1460	11	320	10	10	0	10220	16	14 2 16	63 and 64	—	—	—	—	—	—	9906	13¾
38. Do.	2050	15	2600	21¾	2940	13⅜	1880	8¼	200	0	0	0	9670	15	14 1 14	55 to 57								
39. Lever Edge, near Bolton (Arley)	3670	19	3170	13½	2640	10	1890	8⅛	550	0	20	0	11940	12⅜	15 0 20	50 to 54	—	—	—	—	—	—	—	—
40. Brocklehurst's Victoria Colliery (Arley)	2720	17½	2610	18¼	2150	11	1830	8½	1060	7½	120	0	10490	14¼	14 3 8	43 to 48	—	—	10030	13½	—	—	—	—
41. Do. do. do.	2950	17½	2740	18¼	2370	12¼	1810	8½	250	0	20	0	10140	14⅜	15 0 0	45 to 48								

amount of time and manipulative skill than is possessed by the majority of the profession. When it is required that a coal should be tested, it is necessary to be very careful in the sampling. The author invariably took the one-tenth of a ton to be operated upon from the material on its arrival at the works, and without any selection, except when the trial had a speciality. Particulars as to the coal under test were carefully withheld from *employés* who might have an interest in the result. As much care is needful in sampling for professional analysis, an average sample of about 20 lbs. weight is essential for a reliable test.

As it is desirable that there should be a uniform method of stating the results of testing coal, coke, and gas, the author submits Table No. 3, kindly supplied to him by Mr. John Collins, F.C.S, F.G.S., of Bolton. This form gives as much information as is required, and no more. One item of information given is interesting, as showing the amount of moisture conveyed by gas, and the author calls attention to this fact as deserving consideration. What would be the effect on the illuminating quality by its removal? and whether a cheap and simple method could not be adopted for desiccating gas, and so preventing the freezing of the water in gas supplied to railway signals, &c.? The average quantity of water conveyed by coal gas at a temperature of 60° Fahr. is about 250 grains per 100 cubic feet of gas, or more familiarly one gallon of water is carried forward by each 30,000 cubic feet of gas.

TABLE No. 2.

Sample of Page for Recording Tests of Gas Coal.

Name of coal or cannel . . Bridgewater cannel (selected pieces).
,, pit . . . . . Water Gate.
,, proprietor . . . Bridgewater Trustees.
Date of trial . . . . . Aug. 15, 1878.

Hour.	Meter Indication.	Make each Quarter Hour.	Make Hourly.	Pressure on Jet Photometer.	Candles.	Hourly Average Candles.	Thermometer.
8.45	086080	—	—	—	—	—	—
9.0	134	54	—	·94	7	—	64°
9.15	186	52	—	·94	7	—	,,
9.30	242	56	—	·64	13½	—	,,
9.45	303	61	223	·35	24½	13	,,
10.0	358	55	—	·33	25	—	65°
10.15	421	63	—	·34	24½	—	,,
10.30	488	67	—	·36	24	—	,,
10.45	556	68	253	·40	22½	24	,,
11.0	627	71	—	·42	21½	—	,,
11.15	698	71	—	·45	20½	—	,,
11.30	770	72	—	·48	19½	—	,,
11.45	839	69	283	·51	18½	20	,,
12.0	904	65	—	·52	18	—	,,
12.15	965	61	—	·56	16½	—	,,
12.30	087016	51	—	·59	15½	—	66°
12.45	059	43	220	·62	14	16	,,
1.0	095	36	—	·66	13	—	,,
1.15	123	28	—	·67	12½	—	,,
1.30	145	22	—	·69	12	—	,,
1.45	162	17	103	·71	11	12	,,
2.0	174	12	—	·71	11	—	67°
2.15	183	9	—	·73	10½	—	,,
2.30	190	7	—	·75	10	—	,,
2.45	194	4	32	—	—	8	,,

TABLE No. 2.—(*Continued.*)

Hourly Make.	Illuminating Power.	Total.
223	× 13 =	2899
253	× 24 =	6072
283	× 20 =	5660
220	× 16 =	3520
103	× 12 =	1236
32	× 8 =	256
1114)		19,643
10		17·63 average illuminating quality.
11,140	make of gas per ton.	

Weight of coke . . . . 1 cwt. 1 qr. 14 lbs., or 13 cwt. 3 qrs. per ton
Tar and water . . . . 3¼ gallons, or 32½ gallons per ton.

TABLE No. 3.

Form (A) *for Showing Results of Analyses of Gas from Mains.*

By Mr. JOHN COLLINS, F.C.S., F.G.S., of Bolton.

Samples taken.			Barometer.	Temperature.	100 Cubic Feet of Gas yield in Grains.						Mean Pressure.
Date.	Where.	Hour.			Water.	Carbonic Acid.	Carbonic Oxide.	Sulphur.	Ammonia.	Illuminating Power.	
1878 May 15.	Offices	5·0	29·8	60°	259	1·73	4·21	14·92	0·47	17·9	11/10

Form (B) *for Showing Results of Analyses of Gas from Samples of Gas Coals.*

By Mr. JOHN COLLINS, F.C.S., F.G.S., of Bolton.

Description of Sample.	Specific Gravity.	Percentage of				Cubic Feet of Gas per Ton.	Illuminating Power.	Coke		
		Fixed Combustible Matter.	Volatile Matter.	Sulphur.	Ash in Coal.			Per Ton.	Percentage of	
									Ash.	Sulphur.
Bridgewater Cannel . .	1·275	66·31	33·69	1·27	2·64	10260	20·16	Cwt. q. lbs. 12 3 8	4·8	1·21

Discussion.

Mr. R. HUNTER (Stalybridge) said his experience was somewhat different to Mr. Veevers's. He found on referring to the tabulated results (Table No. 1), and taking the first on the list, namely, the Wigan Coal and Iron Company's cannel, the quality of the gas given off during the second hour of the test was stated as 28¼ candles, and during the third hour as 23¼ candles, and the average quality for the whole as 18¼ candles, and he found in every case on the list a similar result. Now, these results did not agree with his experience, and he thought they were rather misleading. He would have expected a better average. He had made repeated experiments with a small apparatus capable of carbonizing 2 cwt. of coal at a charge, and he found almost invariably that the quality of gas given off at the end of the second hour was the average quality of the whole. This was not the result of one experiment only, but of many dozens, and he had verified it in this way. He had a small holder capable of containing about 30,000 cubic feet of gas, and when he was able to test a coal for a week in succession, he allowed the whole of the gas to go into the holder, and tested it when he was certain it contained only the gas from that particular coal, and was not mixed with any other. Observations of half-hour and quarter-hour tests were taken during the trial and averaged, and in almost every case he found the illuminating power to agree with the average of the gas given off during the second and third hours of the charge. About 25 per cent. of the gas was given off during the first three-quarters of an hour, 50 per cent. during the next two hours, and the remaining 25 per cent. during the finish of the charge, which might be two or three hours. The gas made during the last three hours tended simply to dilute the gas made during the first three-quarters of an hour, and striking off these, and taking the average of the others, it would be found that it gave a fair average of the whole gas made from any particular charge, and this almost invariably agreed with the gas passing off at the end of the second hour.

Mr. T. B. BALL (New Wortley) said, although the paper gave the quantity of gas produced, and the illuminating power, there were other items which should enter into any calculation of the value of a given coal besides these; and they might perhaps counteract any additional value the coal might seem to possess, as far as its illuminating power was concerned. The value of a coal might be estimated at so much per ton; but if there was taken into account the quantity of tar and ammoniacal liquor the coal would produce, a very different result might be arrived at; because, certainly in the Leeds district, some coals would produce twice as much ammoniacal liquor as others, and as the tendency of this product was to advance in value, it formed an essential factor in any estimate of the value of different samples of coal. With regard to the value of the gas given off in the latter part of a charge, it seemed to him they not only obtained a very small yield of gas during the latter part of the charge, but what was yielded seemed to deteriorate that which had been given off in the first instance, and might perhaps lead to an erroneous conclusion as to the value of any special coal. If they were careful to take the charge out as soon as the better part of the gas was given off, it would perhaps pay considerably more than leaving it in so long, and letting the small portion of gas, which came off last, mix with that given off at the beginning. Of course, it was impossible, looking for a short time at so many tests as had been appended to the paper, to pick out particular instances; but it seemed to him that the residual products must be taken into account, for if gas managers were to meet the competition of the electric light, they must depend more on their residual products, and hence, in order to sell gas as cheaply as possible, they would have to use those coals which would give the best results, and the most valuable residual products.

Mr. A. EDWARDS (Taunton) said some coals, although very rich, took a very large quantity of heat in getting the gas

out of them. People should bear this in mind when purchasing coal by advertised testings. He had in his mind a coal which they constantly used in his district, which would produce in ordinary working 5000 feet per mouthpiece. It was a rich coal, and was supplied at a very low rate; but comparing it with other coals which cost more money, it was not so valuable. Using another coal, which would produce about 10,000 feet per ton of 17-candle gas, he could get 25 per cent. more work out of the retorts in the same time. This was an important consideration when gas managers were hard up for gas in winter.

Mr. R. O. Paterson (Cheltenham) said he was not quite clear upon one point of Mr. Veevers's paper. He should agree with him as far as his arrangement for distilling the coal went, which appeared to consist of a double pipe on the ascension-pipe; and in charging the retort in the ordinary way, he passed the gas from the retort by a bye-pass arrangement to a special condensing, purifying, and measuring apparatus. This appeared to him quite intelligible; but when he came to test the illuminating value of the gas by a series of observations on the jet photometer, and added up those readings and averaged them, he was afraid the test was hardly reliable. As to the quantity of gas produced, he saw no reason why it should not be perfectly correct as a practical test, but on the question of quality he did not think it was satisfactory. The jet photometer was by no means a reliable instrument for estimating the illuminating value of gas under any circumstances, and least of all if gas from cannel coal was being tested; for, in the first instance, gas of 30 to 40 candle power might be obtained, and in the latter part of the charge only 10 or 15 candle gas. But he thought the object of Mr. Veevers in his paper was to give a reply to the advertised tests of certain coals. These tests were presumably made in the laboratory, under very favourable conditions; and managers knew it was difficult in practical working to come up to laboratory tests. Mr. Veevers had given practical tests, and as a justification for them, and as a proof of their correctness, he stated the temperature of the gas at the meter at which it was measured, from which he probably meant to infer that they had thus obtained a satisfactory test, because he had shown that he had cooled the gas down to a proper temperature before measuring it. This, so far as it went, was quite correct, but if coal was to be tested for its true value, there must be some other conditions fixed in order to make it perfectly satisfactory. It must be known what was the temperature of distillation. By Mr. Veevers's arrangement, supposing in a setting of seven retorts a bottom one was shut off, and the coal was tested by it, a less favourable result would be obtained than if the middle retort in the setting was taken, simply because the middle retort would be hotter than a bottom one. It was, therefore, quite as much a question of the temperature of distillation as of the temperature at which the gas was measured, the former being the more important of the two.

Mr. W. Carr (Halifax) said that some short time ago there was a warm discussion in one of the Associations, which was afterwards continued in the correspondence columns of the Journal, and there was much difference of opinion expressed about the testing of coals. He thought that if members would only bring their views with regard to this matter forward at such meetings as the present one, instead of stoutly asserting to each other, as they did, that certain results were impossible, it would be infinitely better. One gentleman in one part of the country obtained one result, and another in another part said it was impossible that such a result could be obtained by any reasonable process, and so there was a great diversity of opinion existing upon this subject of coal analysis—more perhaps than upon any other. To his (Mr. Carr's) mind, what was wanted was a satisfactory system of testing—a system which could be universal in its application; but this was a very difficult thing to obtain. He, like the last speaker, did not consider the method as now brought forward in any way a satisfactory one. In the first place, he would take exception to the retort itself, which he assumed was one in an ordinary setting of retorts, subject to all the variations of temperature that such settings were subjected to from time to time. To obtain anything like a satisfactory result, it would require very careful watching and timing. Again, he did not care for the jet photometer that was used. It was not reliable at all; and, besides, to test gas as it passed by any given point was altogether unsatisfactory. The only reliable test he could accept was by getting the whole of the gas from a sample of coal into a holder, and then testing it after its mixture had been completed. For instance, in sample No. 2, in Table No. 1 appended to the paper, there were 50 feet of gas of negative quality, having no illuminating power whatsoever, given off in the fifth hour. There was stated the average illuminating power over the whole time; but they had no idea of what the effect of this negative quality gas would be when distributed through the luminous gas which preceded it, and this was a very important consideration. It was a mystery to him what the gas was composed of which had no illuminating power. There might possibly be something in it which would tend to destroy the luminosity of the other gases, by increasing the rapidity of combustion, or otherwise affecting the flame when the gases came to be consumed, and thus bring down the illuminating power in a greater ratio than was indicated by the 50 feet of non-luminous gas. The best plan, in his (Mr. Carr's) opinion, was to have a gasholder, to put the whole of the gas into it, and then test it after it had been mixed together. Mr. Ball had touched on a very important question with reference to the testing of coals when he referred to the residual products. He (Mr. Carr) had tested a great many samples of coal at different times with an experimental apparatus, and had always tested for the residual products as well as for the quantity and quality of the gas produced. He had noticed that the same coal would give very different results under different temperatures, and that he obtained a less quantity of gas and a less illuminating power with a larger quantity of tar from the same coal. He had found very often that coals which gave a low illuminating power, and not quite so large a quantity of gas, gave a sufficiently large quantity of very good tar to make up for the loss in quantity and quality, and on this account it might be considered good gas coal. In making analyses and estimating the value of different coals for the benefit of his Committee and himself, he adopted the following plan:—He took 18-candle gas as being worth 3s. per 1000 cubic feet, or 2d. per 1000 cubic feet per candle; the coke at the selling price, whatever that might from time to time be; and the tar and liquor, ditto. In working them out in this way he was often very much surprised with the results. For instance, the same coal worked off at different times and temperatures would give widely different results as far as the details went, but the sum of the results would be pretty much the same. Sometimes he would get a large quantity of tar with a comparatively small quantity of gas of low illuminating power, and at other times plenty of rich gas with very little tar. But the money values, reckoned out in the above way, would generally balance each other; and, therefore, coals which gave a large quantity of thin tar, although they might not give so much gas as others, were not to be despised as gas coals, nor could their value be fully appreciated without taking this item into consideration. They were not only useful on this account, however, but also from the fact that they worked off very freely, and gave very little trouble by choked ascension-pipes and that kind of thing. On the other hand, gas managers had coals coming to them with splendid printed analyses (which ignored the question of tar altogether), and while these analyses might be pretty well borne out as far as the quantity and quality of the gas to be obtained from them was concerned, the coal was very difficult to work, and the hydraulic main would soon be filled up with pitch if the working was not very carefully conducted. He should like to hear the opinion of Mr. Hislop on this question. The more it was ventilated, and the more freedom there was among the members in giving expression to their opinion, the more likely would they be to get at some settled idea as to the value of coals.

Mr. G. R. Hislop (Paisley) said he had listened with no little interest to the paper and discussion; and he must say that, in the main, he very much agreed with Mr. Carr. In the first place, the coal tested should represent the entire seam; and, if possible, should be taken from two or three different parts of the seam in proportion to the output. There were also many other circumstances which went to affect the results obtained—too many, indeed, to refer to at present. The amount of water in a sample of coal when examined very much affected the results, as within certain limits a difference of each 1 per cent. in the coal would affect the gaseous products to the extent of 5 per cent. It was further most essential to value all the products from the coal; as to estimate the gaseous products apart from the solid and liquid products rendered the analysis altogether incomplete. In England the secondary products were, perhaps, of higher importance than in Scotland; but he had made it a point for many years to most carefully estimate the commercial value of tar, liquor, and coke, which in his analyses were summed up and represented in one figure. They were accurately ascertained in the commercial way, and therefore a simple sum in proportion would determine the relative value of coals taken

in that connection. A good deal of discussion had arisen as to the scale of magnitude on which these analyses should be conducted; but analysts were inclined to think they were entitled to show what was contained in any given sample of coal, and that those who had to manufacture from it on a practically large scale must do their utmost to come as near to the analytical results as possible. It would be a mistake, however, in all cases, to expect to find results on a large scale such as were given in an analysis. Every gas manager, according to his mode of working, the nature of his settings, and the heats with which he worked, should make a certain deduction, according to his experience, in each case, for the difference which would exist between an examination on a somewhat small scale and one on a commercial scale. If these matters were properly considered, no manager would experience difficulty in taking a printed analysis in guiding him as to what he would obtain in general working. With regard to the charges being protracted too long, he had been in the habit for many years of using plugs in the top of the ascension-pipes, and found them exceedingly useful in time of defective quality or scarcity of gas, when they required to take the retorts quicker, in order to maintain a supply of gas, as by raising the plug the condition of the charge could be ascertained, and when it was found the charges were sufficiently exhausted the diluent gases could be escaped, or the retorts re-charged, and thus valuable time would be saved. He found on Sundays, when labour was suspended, they were very useful; because, instead of slackening the retort-doors, he put the plugs up, and allowed the inferior gases to escape through the roof of the house.

Mr. T. Anderson (Bath) having made a few remarks,

Mr. C. R. Mead (Sutton) said it appeared to him there was one omission which was very often made when results were given of the testing of gas coal, and that was the temperature of the retorts in which the coal was distilled. They all knew very well that different results were obtained in different gas-works where the same quality of coal was used. For instance, there was a coal they all knew very well in the South—the ordinary Pelaw Main gas coal—from which some managers were able to get paid for 8000 feet of gas per ton, whilst others obtained 9000 feet per ton, and at one works in the neighbourhood of London they were paid for over 10,000 feet, the leakage in each of the gas-works being, comparatively speaking, equal. There was no doubt in his mind that at these different works the variation in quantity was obtained entirely by the difference of the heats at which the retorts were worked. Some coal would give vastly different results with different heats in the working; and hence he believed there was no practical analysis of coal worth anything unless the temperature of the retorts in which it was distilled was stated. It was not fair to distil at a low temperature, and then give the volume of gas as being small from a certain quality of coal. He would further say to those who managed small gas-works, and had no weighing machine, that there was something else to be guarded against in testing a sample of coal. Most gas managers had been visited by gentlemen who had agencies for the sale of coal, and a very common practice amongst them was to offer to "send a truck of, *say*, 5 tons to test the coal by." Now, he would advise his friends always to get means to weigh the sample of coal thus sent before testing it; for he had found, in some cases, that the first truck, which should have contained 5 tons, contained nearly 6 tons, and if they looked at the result of the testing of the first truck of coal, and then tested the coal bought in bulk, which would be only 5 tons to the truck, they would get a very different result from what was in both cases a truck of coal.

Mr. W. Sugg (Westminster) said that, as an experimentalist, he was much interested in this paper. Mr. Veevers had opened up a subject of very great interest indeed by the manner in which he had carried out his results, showing what could be obtained from coal at the different hours of the charge, and he had not found anywhere else results given so fully as they were in these experiments. Next, with regard to the manner in which the experiments were carried out. A somewhat similar plan had been adopted a good many years ago by Mr. W. Mann, of the late City of London Gas Company; namely, taking off from a retort-bench the centre retort, registering the quantity of gas made from it, and carrying it off from the ascension-pipe to a separate set of purifiers and condensers. But Mr. Mann found that taking off the whole of the gas was very inconvenient, because he could not get a gasholder large enough to contain all the gas made from a large-sized retort. He therefore adopted the plan of passing the gas through a meter having a fractional meter on the top of it; and, by this means, he obtained an accurate sample of the whole of the gas which was produced, and passed through the large meter. This small quantity was collected in a little gasholder and analyzed. The results he obtained were perfectly independent of tar or liquor, which could be made by the apparatus, and this had always been a difficult thing to ascertain, especially in small experiments, though a small apparatus would be found most useful, from the greater ease with which the temperature in the whole of the working could be regulated. For, in the first place, with regard to the temperature of distillation, this could be much more easily regulated by the use of gas than by means of coke—in fact, it could be regulated to the greatest possible nicety. M. Audouin, of Paris, had carried this out very well, in a small apparatus in which he used only 300 grains of coal, and obtained surprisingly correct results. This, however, he (Mr. Sugg) thought was much too small a quantity. The furnace should be heated entirely by gas and air burners, and by this means the temperature could be maintained to a nicety. It could either be regulated by the melting point of different metals, or by the mode M. Audouin adopted of taking a piece of platinum (or iron) of a certain size, dropping it into water when it was at its greatest temperature, and seeing how much the temperature of the water was raised by it. This would give a very good index to the heat of the retort. Then the only way of obtaining the tar and ammoniacal liquor in a small experiment was, he (Mr. Sugg) thought, by collecting the gas over water, and in this way the tar could be collected, but the ammoniacal liquor it would be almost impossible to estimate, unless the apparatus were kept going for some considerable time. He thought Mr. Carr had slightly misunderstood the direction of Mr. Veevers's experiments, because he said the only way to get at an accurate result of what was contained in the coal was by taking the whole of it. This was, no doubt, perfectly correct as a commercial experiment, but Mr. Carr had lost sight of the point that Mr. Veevers evidently intended to work out, which was to show what was the illuminating power and quantity of gas obtained during every hour of a charge of coal. This had been tried in an inefficient way by a few persons only at home and abroad. It might be within the recollection of a great many of those present that at one time there was considerable doubt as to when the greatest amount of sulphur was given off, whether from the first, second, or third hour of the charge. It was generally believed that the greatest quantity was given off during the last hour, but some experiments which he had the pleasure of seeing performed by Mr. T. N. Kirkham at Fulham showed conclusively, as far as he could ascertain, that the last hour of the charge did not give off any greater amount of sulphur than the first. Since that period he had heard remarks on the subject made by foreign gas engineers, who, many of them, use much higher heats than were common in England, and there did seem something remarkable in the results they obtained. He was struck by the remarks of Mr. Hislop who spoke of the mode of testing which he adopted; but this gentleman did not seem to recollect that heats in Scotland were much higher than those used in London and the neighbourhood. This was one of the main points to be attended to in the experimental trials of coal, and this point could only be determined by experiments on a small scale in the direction which Mr. Veevers had pointed out, and with a furnace regulated by gas.

The President said that in the very interesting discussion which had followed this paper there was yet one condition, essential to the accuracy of tests for the purposes of comparison, which appeared to him to have been overlooked, and this was the temperature down to which the process of condensation had been carried. In various experiments he had conducted in testing coals, he had found considerable difference with the same coal, in the illuminating power of the gas when it was condensed, say, to about 40° Fahr., and when gas from the same coal was condensed to 60° Fahr. He regarded it as absolutely necessary for the purpose of determining the comparative values of different kinds of coal, that in testing them the same temperature of condensation should always be observed.

Mr. Veevers, in reply, said he feared that some points of his paper had not been distinctly heard, because he had certainly mentioned tar and ammoniacal liquor as entering into the estimation of the value of a coal. The object of the paper was not to go into elaborate scientific tests, but to point out a method by which an ordinary working manager, who had not much time on his hands to devote to scientific analyses, should be able to check the quality of the coals he was using in his works. Of course, to this simple method could be added any further scientific investigation which might be

needed—as to the different temperatures to be employed, and more elaborate results as to the tar and ammoniacal liquor obtained. Time would not allow him to answer the whole of the remarks which had been made, but he might say broadly that his object was to give a simple method of testing coal and cannel. He gave the result in the quantity of gas made, because it rather surprised him to find that, in practical working with coal and cannel, he afterwards obtained somewhat similar results to those realized without the use of a gasholder, and it was the absence of a gasholder and tank which made his plan so economical in small works.

(III.)
RETORT FURNACES.

By Mr. Frank Livesey, of London.

The object of this paper is to give to the Association an account of some successful experiments to reduce the retort fuel account at the South Metropolitan Gas-Works, which has been accomplished by the adoption of gas generator furnaces and other arrangements. Gas generator furnaces, or furnaces for the conversion of coal or coke into a gas fuel, chiefly carbonic oxide, have of late received much attention in gas-works in France and Germany, with very favourable results; the advantages from them being not only the saving in fuel, but also the greater heat to be obtained and the freedom from dust in the retort-flues.

The theory upon which the carbonic oxide furnace is constructed is a well-known one; but it will perhaps render the paper more complete to state it. When air enters through the bars or at the lower part of a furnace, the oxygen combines with the heated carbon and forms carbonic acid (CO_2); but should there be a deep layer of fuel—say 3 or 4 feet—the supply of oxygen becomes less in proportion to the carbon, and the carbonic acid takes up another equivalent of carbon, and carbonic oxide (CO) is formed. The resultant mixture of gases, according to one authority, should be composed of carburetted hydrogen, nitrogen, carbonic acid, and carbonic oxide, in about the following proportions:—

Combustible gases .	carbonic oxide . . .	25 per cent.
	carburetted hydrogen	11 „
Incombustible gases.	carbonic acid . . .	4 „
	nitrogen	60 „

In the Journal of Gas Lighting of July 29, 1879, "Isca" gives the composition of gases from a grate generator properly supplied with steam as under:—

Combustible Gases.			Incombustible Gases.	
CO	H		CO_2	N
20·4	9·8	. .	9·3	60·5 = 100
18·9	9·8	. .	9·2	62·1 = 100
20·6	10·6	. .	9·3	59·5 = 100

If there is a very strong draught, or if the air entrance be large in proportion to the capacity of fuel, the quantity of the two incombustible gases will be greatly increased, thus destroying the object to be attained. The combustion of the fuel is most intense at the bottom part of the furnace, becoming less as the top of the fuel is reached, where a greater heat than a dull red indicates the presence of carbonic acid. It is necessary that the air supplied to burn this gas should be heated previously to its being delivered in the combustion chamber, below the retorts, and to do this economically several plans have been tried. The object to be attained is, of course, to heat the air by means of the waste heat, and naturally the main flue is at once suggested. Unfortunately, the main flue in this case, as in many other works, was at the top of the beds, so rendering necessary a strong draught to pull air down into the combustion chamber, and a still stronger draught in the furnace, which is at a lower level. This is very objectionable, for, should there be any cracks in the furnace, air will be drawn in, and will destroy more or less of the carbonic oxide.

In several French settings that have been especially arranged for gas furnaces the main flue is carried beneath the retort-settings, and the air for the combustion of the carbonic oxide is there heated; one plan being to pass the air through the flue in a number of small pipes, somewhat after the plan of the battery condenser, where the gas represents the waste heat, and the cooling tubes the air to be heated. This plan of heating the air, though certainly the most economical, cannot in all cases be adopted. One plan tried was to draw the air backwards and forwards up the sides of the furnace itself; but in this there is an element of danger, for should there be a crack between the cold air flue and the furnace, air will be admitted into the furnace, and so burn the carbonic oxide where the heat is not required. This difficulty can be overcome by making the air-flues of cast-iron tubes; the air may then be heated in the way just spoken of, or underneath the bottom retort.

From many different furnaces that were tried, two successful ones are here selected for description. The first (Fig. 1) was constructed in the coke-hole of a stage house, after the usual form of a gas generator furnace. The opening for charging was made to be air-tight when closed; the flue taking gases into the combustion-chamber in the setting. There were four cast-iron plates sloping to the fire. The lower ones supported the bars, which in this case were old inch tubing, and they projected out some distance in front, in order to move them about and break up the clinker. Upon these lower iron plates also a constant stream of water was allowed to run, the greater part of which was converted into steam, so keeping the upper plate cool, as well as checking the great heat at these air entrances. The front and sides were stepped back from the grate in order to prevent the air creeping up the sides, and so escaping the passage through the fuel—a very necessary condition. The position of the charging-hole and the shape of the furnace must be well considered, for should there be at any place a less depth of fuel than 3 feet, the percentage of carbonic acid will be large, and heat will be generated in the furnace instead of under the retorts. Furnaces built previous to this one, where fire-tiles had been used in place of the iron plates, and where neither water nor steam was supplied, melted away so rapidly as to render them useless. It was found necessary to supply steam or water at all places where air was admitted, as the decomposition of the steam reduced the temperature where it was most intense and was not required, and supplied fuel higher up.

In a paper on "Gas Generator Furnaces" in the Transactions of the French Society, it is stated that as much heat is required to decompose water as is given off by its combustion. The advantage to be gained, as before stated, by the use of steam, is to reduce the temperature at the grate and air entrances, where the intense heat will melt everything with which it comes in contact, and supply it in the mass of the fuel where it is useful.

The hot air in this furnace was supplied by two 8-inch pipes running into a flue of the same area passing under the flue of the bottom retort, and then into the combustion chamber under the centre middle retort. The size of this furnace, which heated the whole length of a through bed of seven retorts, was, at 2 feet above the bars, 5 feet long and 3 feet wide. The area of the grate was 33 in. × 9 in. = 297 square inches, less three bars, 132 square inches; leaving 165 square inches. The area of the hot-air flues, two 8-inch pipes = 100 square inches; but the draught being much greater through the pipes, the area may be taken roughly as 200 through the pipe, against 160 through the grate.

After working for four months there was little or no sign of burning away, as the furnace was not certainly 1½ inches wider at any part than when first built. The saving of fuel was on the average about 20 per cent. It is essential that the fuel as it burns away and reduces in bulk should not leave the sides, and so make a passage for the air, but, on the contrary, should wedge itself in; for should the air find a passage up the sides or ends of the furnace, carbonic acid gas will be formed, and the bricks will be rapidly burnt away. It is better that the hot-air flues should exceed in area that of the grate; they can then be closed until the best results are obtained.

The experience gained from this furnace, and from several others that were tried, led to the conclusion that the chief economy in working was obtained by the deep layer of fuel and the heated air supply. If the same results could be obtained in an ordinary setting, it would certainly be an advantage, as a large amount of brickwork would be saved, and the disadvantage of having the coke-hole blocked up with so many large furnaces would be removed.

The accompanying drawing (Fig. 2) shows the plan adopted to carry out this idea. The furnace in an ordinary stage retort-house was cut out, and an opening cut through the arch below, as shown in the drawing. Two furnaces were used in this case, one at each end of the through bed. The opening in the arch which formed the grate is 25 inches long, 2 inches wide, increasing to 21 inches wide in the body of the furnace, and 4 ft. 6 in. long, leaving a depth of 5 feet from the grate to the holes admitting hot air. The ordinary furnace door was removed and replaced by an air-tight one. It was also raised to keep a good depth of fuel in the furnace. Steam is supplied to the grate by means of a ½-inch pipe having six small holes to direct it into the fuel. The air for combustion of the carbonic oxide is heated under the flue of the bottom retort, and is delivered in the furnace, above the level of the fuel, about 9 inches below the springing of the furnace arch.

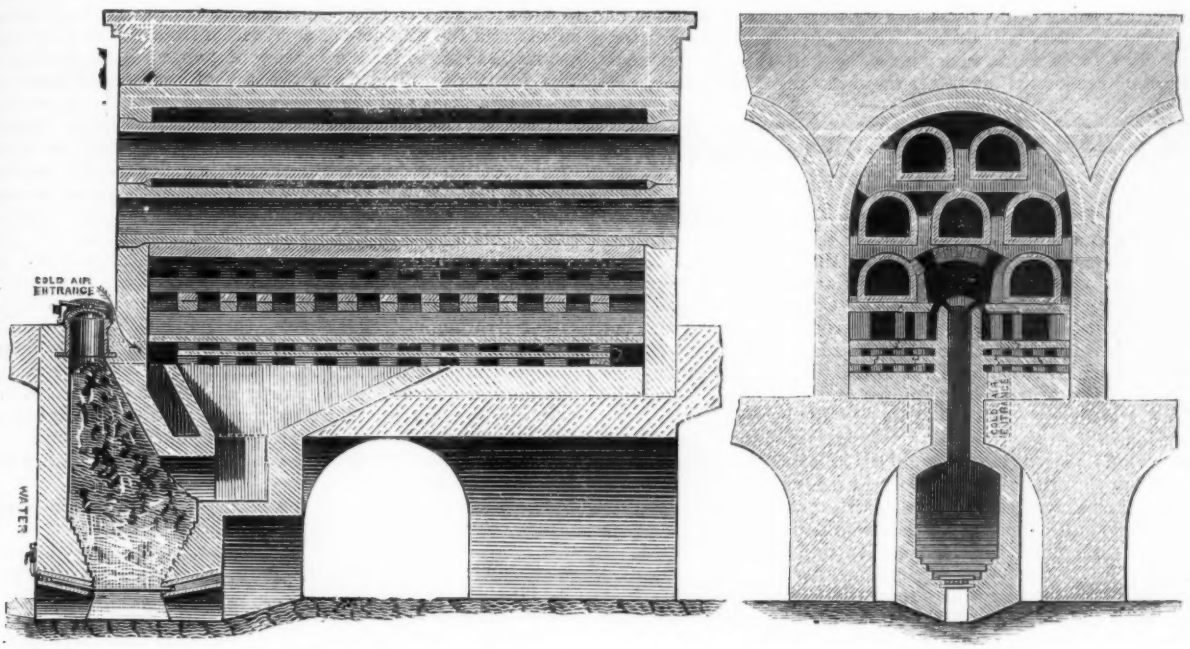


Fig. 1.

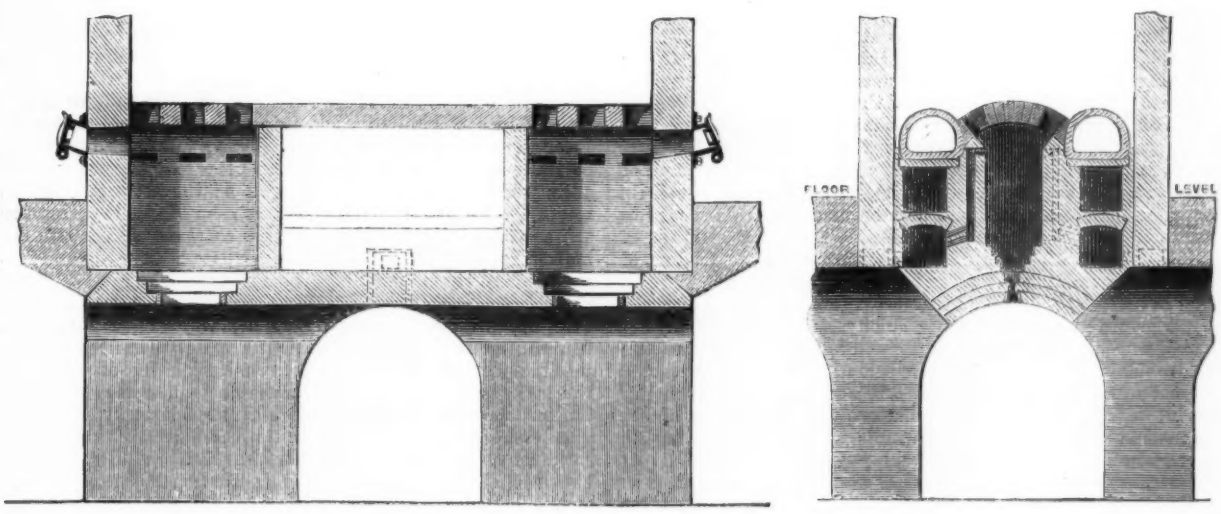


Fig. 2.

The consumption of fuel was quite as low in this as in the first one described, being about 20 per cent. saving on the ordinary furnace, and it possessed the advantages of making very little breeze, and requiring but little attention. The fire was not once raked out during the three months it was at work. The grate area was 25 inches × 2 inches = 50 square inches for each furnace, and the hot air supply about 28 square inches; but as the draught was much greater here than through the fuel, as much air entered, and probably more. There was no perceptible increase in size after three months working, and it was then only let down because it was no longer wanted. The heat in this setting was much higher than in any of the adjoining ones, while the fuel consumed was less, and the firemen's labour reduced. No fire-bars were used, and the only attention required was to prick out the grate occasionally, and to fill up the furnace as required, which was at longer intervals than in the ordinary furnace.

Having given a description of some successful furnaces, it may prove interesting to state the reasons of failure of some of the unsuccessful ones. In one case a large grate area was allowed, with the intention of checking the air supply by means of a damper, but without success, as it proved to be only an ordinary furnace making carbonic acid instead of carbonic oxide, and maintaining a constantly running stream of clinker; or, in other words, a machine for melting fire-bricks. In another design the air was heated by the main flue, and was drawn from the top of the beds; but as the draught was not strong enough in the furnace, the air supply was insufficient, and a large portion of the carbonic oxide passed through the setting without burning. This was shown by taking a plug out of the main flue at a point where it was only receiving the waste heat from this particular bench; a piece of glass was then placed over the hole and made air-tight round the edges with fire-clay. On examining the flue no flame whatever was seen, but on waiting till the glass cracked and admitted air, the gases in the flue at once caught light. In nearly all cases where neither water nor steam was supplied, the melting away of the furnace was so rapid as to make its adoption quite out of the question.

The object of this paper has been to give a description of an application of the gas generator furnaces to heating retorts, and to show where success, and where failure, is likely to obtain. A ready means of analyzing the resultant gases from a furnace would be of use, could such a process be discovered; but, in default of this, the knowledge that the furnace is making carbonic oxide instead of carbonic acid is sufficient, and is very soon gained. It is a pleasant duty to mention that these experiments, which have been so far successful, have been under the superintendence of Mr. J. Somerville, whose perseverance and ingenuity to overcome many difficulties deserve great praise. Mr. Tanner, the foreman of

the Old Kent Road works, has also made some valuable suggestions that have materially aided the working.

In conclusion, the writer urges the necessity of further experiments being made, for as every step in the reduction of working expenses will make the consumption of gas greater, and give to it more varied uses, so will this greater consumption render the manufacture of gas more important.

(IV.)

REGENERATIVE FURNACES AS APPLIED TO THE HEATING OF RETORTS.

By Mr. G. E. Stevenson, of Peterborough.

Two years ago I had the honour to read a paper before you on the subject of "Retort Setting." Although I was aware at that time of the introduction of regenerative furnaces for heating retorts on the Continent, and had seen at Frankfort-on-the-Maine some furnaces at work on the system invented by Herr George Liegel, Manager of the gas-works at Stralsund, I was not acquainted with the details of the system he employs, and did not possess sufficient knowledge of this principle of heating, to justify allusion to it in the paper I then read. Being a short time afterwards placed in communication with Herr Liegel, and believing that the regenerative principle was a more scientific mode of heating than the usual method employed, I devoted some time and attention to the examination of the different systems of generator furnaces in use, and to the Liegel generator in particular, being early convinced that this system possessed advantages over other forms of regenerative furnaces, in the greater simplicity of its construction, and more direct application of the productive gases to the retorts requiring to be heated.

The principle of a regenerative furnace may be briefly stated as follows:—Instead of constructing the furnace so that immediate and complete combustion of the fuel shall take place, it is so designed that the primary supply of air, entering at the bottom of the furnace, shall be sufficient only for the combustion of a portion of the fuel lying nearest to the point of ingress of the air, and that the carbonic acid gas generated by the combustion of this portion of the fuel shall, in passing through a further considerable stratum of coal or coke, as the case may be, yield up a portion of its oxygen to this mass of fuel, and become thereby reduced to carbonic oxide. The oxygen absorbed by the stratum of fuel through which the carbonic acid gas, as the product of the initial combustion, passes, maintains the whole mass of fuel in a state of slow and partial combustion, and the hot gases passing away (consisting chiefly of carbonic oxide) are capable of being rekindled and finally consumed to carbonic acid. This is effected by introducing at the proper place a second supply of fresh air, heated to a temperature sufficiently high to cause the ignition and subsequent combustion of the carbonic oxide gas. By this means a perfect and complete combustion is finally effected, and, what is a matter of great importance, this final combustion is made to take place in intimate contact with the object requiring to be heated, the heat of a flame being always much greater than the heat of the extinct gases resulting from the combustion.

The name "regenerative" furnace was given to this principle of heating by Dr. Siemens, when he applied it to his steel puddling furnaces. In an analogous form to that of the original Siemens furnaces, the principle has been applied by the Paris Gas Company to the heating of their retort-settings. The arrangement is a very complicated one. The primary combustion takes place at some distance from the retorts, the gases of combustion being conducted by flues to the retort-settings, and there mixed with a fresh supply of air, which has previously been heated to the required temperature. To effect this, the secondary air supply has to be conducted through channels heated by the waste gases from the retort-settings. These waste gases are first passed through the channels, in order to heat them to the requisite degree, after which they are turned off, and a fresh air supply is conducted through the same channels, until they have become too cold, when the process is again reversed. By an arrangement of valves the changing of the currents of air and gases is effected simultaneously, two sets of channels receiving alternately the hot gases and the fresh air. This system is very complicated and expensive, and though it may prove successful where capital expenditure is not a matter of much importance, the competition existing between our undertakings in regard to the price charged for gas would present a serious obstacle to the general introduction of so costly a carbonizing plant in this country.

Another form of regenerative furnace existing and finding favour on the Continent is that of Herr Oechelhäuser, a manufacturer of gas plant, and also Engineer to the German Continental Gas Company. In his system a furnace is built at the back of the retort-settings, in the shape of a square cupola, and the products of combustion from one such furnace are made to serve for the heating of two settings of retorts. The furnace is filled from the top of the retort-bench by means of a hoist, and the gases are introduced into the retort-setting from the back. The secondary air supply is heated by being conducted along flues passing up and down the back of the settings and beneath the bottom flues of the retorts. In this manner the complicated alternating system of the Siemens furnace is avoided, and much economy in construction effected. There are, however, few retort-houses in this country in which such a furnace could be introduced. In large works the prevailing custom is to place the retort-bench in the centre of the retort-house, the retorts being either "throughs" or situated back to back. In smaller works, where the retort-bench is single, it is usually placed close to the back wall of the house, and I take it for granted that few engineers, in designing a retort-house, would be prepared to allow room for constructing such a furnace behind the retort-settings. Moreover, it would not be desirable, in any but very large works, to have furnaces capable of heating two retort-settings at a time.

The next adaptation of the regenerative principle which merits consideration is that of Herr Liegel, of Stralsund. In this system the furnace is placed beneath the retorts themselves, as in the ordinary method of firing. The accompanying illustration (Fig. 1) shows a setting of eight retorts, as erected at the Maidstone Gas-Works, in which the furnace is of the most approved form. It is constructed very deep, and of a peculiar shape. At the bottom is a narrow aperture or slit for the admission of air, and immediately above the slit the furnace spreads out to a width much greater than that of an ordinary furnace. From the point of extreme width the furnace diminishes upwards, the courses of brickwork being set over gradually as the furnace ascends. The front part of the furnace is brought forward below the ground level, and formed into a kind of sack, into which the fuel is tipped through an opening in the floor. This part of the furnace is partially divided from the portion beneath the retorts by an arch, which supports the front wall of the setting. At the top of the furnace, on either side, are the channels delivering the secondary air supply from flues constructed beneath the bottom retorts. The currents of air pass backwards and forwards along these flues, and become warmed by the heat from the bottom retort-flues immediately above them. It is, however, not absolutely necessary to heat the air in the Liegel furnace, because the combustible gases, never having left the proximity of the furnace, do not require igniting afresh, as in the case of the Siemens furnaces. The slit at the bottom of the furnace is formed by large fire-clay blocks built into either side of the furnace. Below the slit the blocks recede rapidly from the centre line, and beneath the slit a small fire-grate is constructed, the sides of which are formed so as to leave air spaces between them and the under sides of the main slit blocks, the purpose of which is to cool the latter, and prevent them from fusing with the heat of the furnace.

The peculiar construction of this part of the furnace is designed to obviate the necessity of clinkering. The intensity of the combustion immediately above the slit is such that the slag runs out of the furnace in a melted condition, and does not clinker and stop up the slit. It is, however, necessary to control the degree of fusibility of the slag. If the slag melts too quickly, and leaves the furnace-blocks clean, these latter cannot long resist the great heat to which they are exposed. Liegel has discovered that if the slag be maintained in a semi-melted or viscous condition, it will, by spreading in a thin layer over the brickwork, protect it from the action of the fire. The draught in the furnace must therefore be regulated to attain this object, and to assist in controlling the fusibility of the slag, the small fire-grate is inserted beneath the slit, and upon this a fire must be maintained (fed with breeze falling through the slit) of such proportions as may be found necessary for the requisite melting of the slag, and freeing the same from the slit-blocks. The clearing of the slit is assisted by the fireman with a light hook, which, being drawn along the slit, removes the semi-melted slag clinging to it. Beyond this, no cleaning of the fire is required. A tunnel is constructed beneath the retort-house floor, for the purpose of approaching the furnace, and for removing the clinker and ashes.

In cases where it is found inconvenient, on account of the presence of water, or from any other cause, to excavate to the depth required for the furnace in its normal form, the

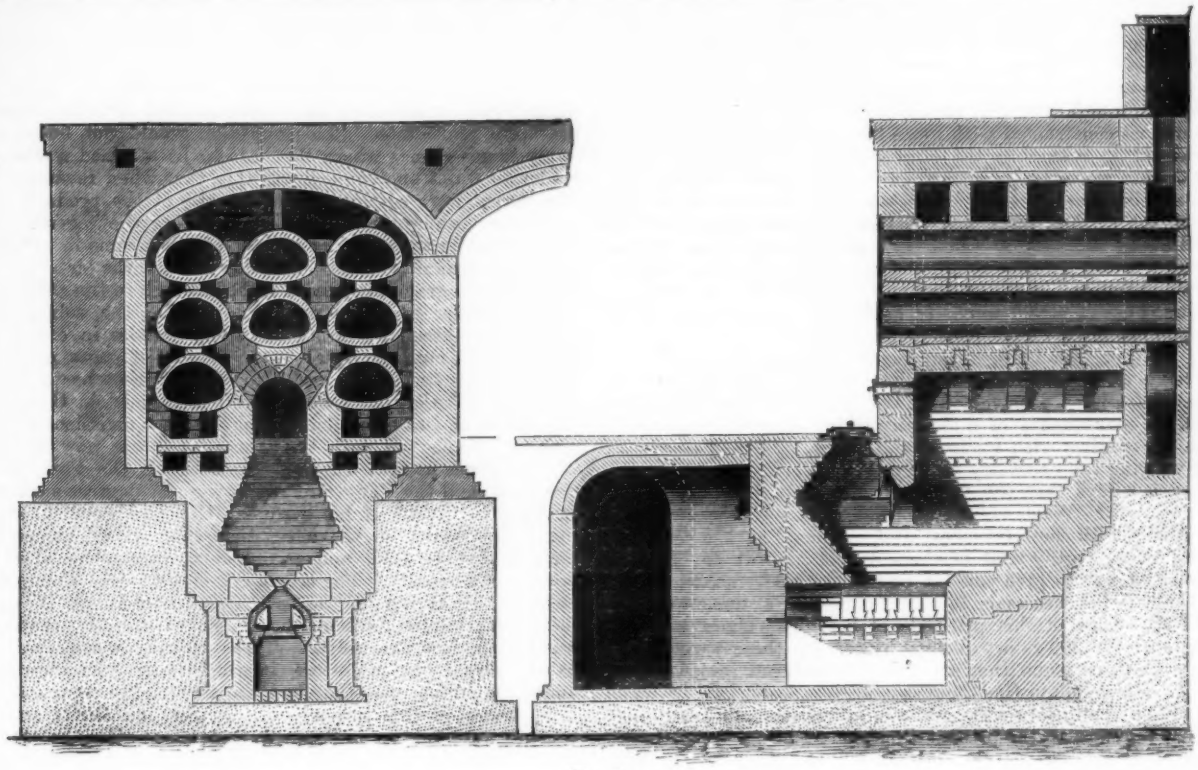


Fig. 1.

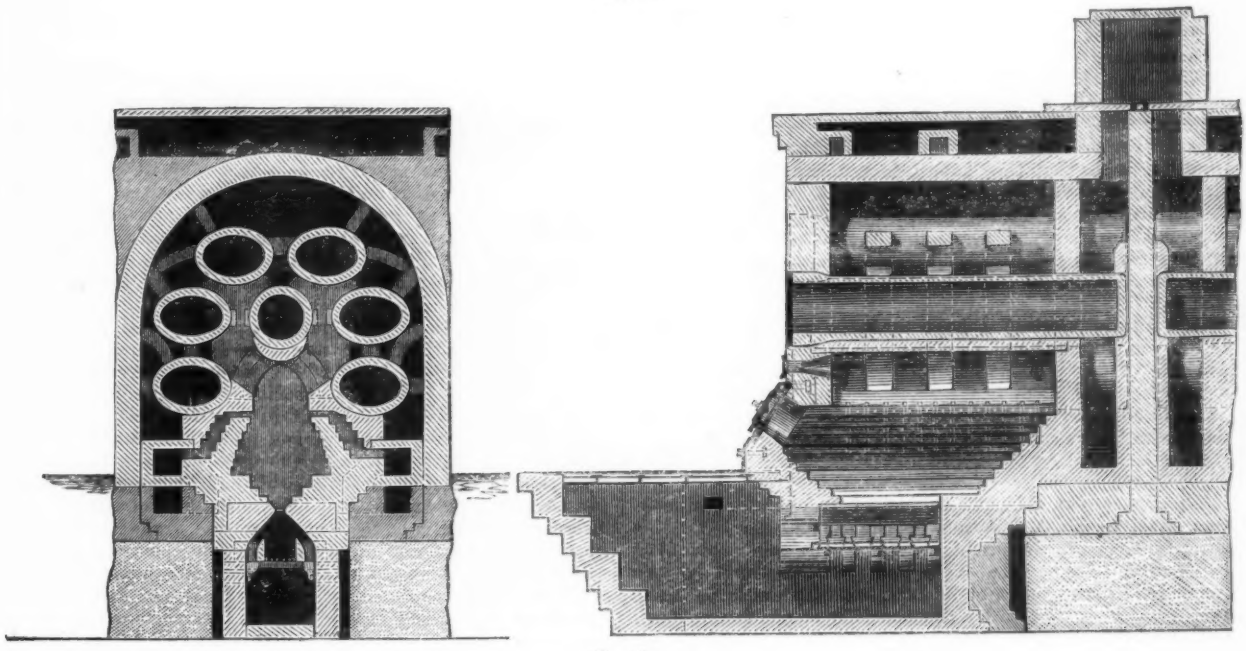


Fig. 2.

system may be applied without the tunnel by constructing the furnace of less depth, and providing for approach to the slit by means of a pit, with steps to descend into it. This method has been adopted in designing the furnace at the Peterborough Gas-Works, where, on account of the high level at which the water stands in the ground, a tunnel could not be constructed. It will be seen, on referring to the illustration (Fig. 2), that in this case the furnace is fired by an inclined opening in the front wall of the setting, and the underground "sack" is dispensed with. This furnace costs less to construct than the deeper ones, but the latter are more perfect in their action and more economical in their results.

The advantages which a regenerative furnace possesses over the ordinary method of heating are mainly greater economy of fuel and greater heating power. The reason for this is to be found in the fact that, for the complete combustion of such fuel as coke or coal, a much greater supply of air must be admitted into the furnace than the theoretically requisite quantity. The speed at which the air must necessarily pass through the furnace to develop the proper heat, and also the impossibility of the whole of the oxygen of the air coming into contact with the carbon to be taken up, compels the admission, through the grate-bars of an ordinary retort furnace, of about double the quantity of air theoretically necessary, and consequently double the quantity of nitrogen, the direct effect of which is to stultify the combustion and reduce the heat. In a regenerative furnace one-half only of the combustion takes place under these unfavourable circumstances. This must be evident when it is considered that the preliminary object to be attained is the production of carbonic oxide (CO), and not carbonic acid (CO_2); the former gas requiring for its formation one-half the quantity of oxygen to combine with an equal quantity of carbon that is required for the complete combustion of the same. The other half of the oxygen is not introduced until the fuel is in a gaseous form, when a much more thorough intermingling of fuel and oxygen is readily attained than can be realized so long as the fuel consists of solid material.

The Liegel furnace possesses an advantage over other forms of generator furnaces in the fact that clinkering is abolished.

The labour of keeping the slit clear is trifling compared with that of the ordinary process of clinkering, which I do not hesitate to say is a strain on the constitution of the firemen, from which they ought to be relieved if it be possible, and it also exerts a detrimental influence on the furnace and the retorts, which cannot be too seriously estimated. In generator furnaces constructed with grate fires, great difficulty is experienced in removing the clinker and clearing the furnace. For this reason experiments have been made in introducing steam into the furnaces. The steam has the effect of rendering the clinker light and friable, and preventing it from adhering strongly to the brickwork of the furnace. This, however, necessitates additional expenditure in fuel to generate the steam, and I believe it will be found that the continued use of steam in the furnaces has a detrimental effect upon the brickwork.

I regret that I am, as yet, unable to place before you the results of a personal trial of the system. I have had one of these furnaces constructed at the Peterborough Gas-Works, but in consequence of difficulties which have been met with in contending with underground water, and also delays in procuring the necessary fire-clay blocks, it is only within the last few days that the furnace has been completed ready for work. Mr. West, of Maidstone, has also constructed four settings with these furnaces; and, although he has not made any very lengthy trial of them as yet, he will doubtless be kind enough to give you his opinion of their merits. It is, however, not necessary to wait for results at home to judge of the value of this principle of heating. There are now upwards of 200 retort-settings heated by these furnaces on the Continent, and they are being introduced into America. The Metropolitan Gas Company of New York, having made trial of the system last year, are so satisfied with the result that they are at the present time constructing a new bench of eight settings on this principle. Also in Newark, New Jersey, two settings are being built. In the most improved settings of nine retorts each, the fuel account is now reduced to 10 per cent., and the production of gas per mouthpiece with ordinary oval retorts reaches 9000 feet per diem. The repairs required by the furnace, if properly worked, are extremely small, a furnace lasting three seasons without requiring to be relined.

In further proof of the economy effected by these furnaces, I will just state that they have also been applied to heating steam boilers with remarkable success. A Cornish boiler at the Stralsund Gas-Works, heated by a Liegel furnace, evaporates 12 lbs. of water per pound of fuel, whereas the proportion for boilers fired in the usual manner varies from 6 lbs. to 7 lbs., or, at the most, 8 lbs. of water per pound of coal.

At a future meeting I hope to be in a position to place before you the results of personal experience in regard to the working of these furnaces. In the meantime, however, I trust others will make trial of this system, and thus be prepared to confirm the statements made by the inventor and those who have adopted his furnaces in other countries.

Discussion.

The PRESIDENT said the subject of regenerator furnaces was novel to the Association, but he did not think on this account that the discussion would be by any means less instructive. He was glad to see amongst them the illustrious inventor of the regenerator furnace, and they would be under very great obligation to Dr. Siemens if he would favour them with his views on the subject.

Dr. SIEMENS said the authors of the two papers before them had drawn a distinction between the furnaces they had described and the Siemens regenerative furnace, but if too much time had not passed since his early experiments it could easily be shown that the furnaces now put forward had a very strong family likeness to the very earliest furnaces he adopted. In the first instance, he naturally confined the regeneration to the air, using a gas producer very much of the form shown in the diagram, in order to supply the furnace with heated gas. In one variety of that furnace in which the currents were not reversed, he used tubular regenerators; but he soon convinced himself that in doing away with the reversing action only a seeming simplification was effected; for it was far easier to maintain in good working condition brickwork loosely piled into a chamber, than flues through the sides of which the heat had to be transmitted. In the one case there was no leakage, and in the other there was, as well as breakages of the sides of the flues or tubes employed. He therefore soon abandoned the tubular regenerator, and confined his attention to the reciprocative regenerator, in which the currents of cold air and of hot products of combustion were reversed from time to time. The gas producer was at first closely attached to the furnace in a similar manner to that shown, but he found that two evils arose from this construction. In the first place, the temperature attainable in such a furnace was much below that which resulted if both air and gas were regenerated. This objection would not, however, apply to gas-retorts where the heat to be attained was only moderate. But another evil was this, that when reversals of the current were employed, the quantity of the products of combustion which was available for heating the regenerator must be larger than the quantity of air that came in to take up this heat again. Hence it followed that the air regenerator became gradually heated right through to the chimney end. In order to attain perfect regulation, the volume of gases which ascended through the regenerators, in order to take up heat, must be equal to the amount of gases passing through the furnace in order to give up that heat. The Paris Gas-Works had been specially mentioned in the first paper, and he was somewhat struck with the omission of his name in connection with them, because it was now nearly 20 years since he first designed furnaces for the Paris Gas Company, and the Vaugirard works were by degrees entirely changed in favour of his system. His arrangement with the Company was to the effect that they should ascertain their saving in fuel, and pay him a percentage of the saving as a royalty. For a number of years the Company returned a saving of 35 per cent., which, as it was their own determination, he might take for granted was not against themselves. These furnaces were supplied from separate gas producers, in which water was admitted under the grates; and they had the air and gas regenerator. The success of this furnace was complete, and other retort benches were put up on the same system one after the other. He admitted that the system was a costly one, and he could see in the recent endeavours to modify the arrangement a natural desire to economize in the first cost. At the same time he noticed a reduction in the percentage of saving from 35 per cent. to 25 per cent., and this was just such a result as he should have expected; because, in order to get the maximum economy, it was essential to have a separate gas producer and the double regenerator. The author of the first paper mentioned the fact of water being introduced at the bottom of the gas producer as a means of improving the draught; but he (Dr. Siemens) must confess that he never looked upon it in that light, and did not see well how it could improve the draught, nor did they want much draught in the producer. The effect was entirely a chemical one. If water or steam was introduced at the bottom of the gas producer, especially when coke was used as the fuel, the decomposition of that water or vapour took place in passing through the lower part of the fuel in the gas producer where the temperature exceeded the point at which water was decomposed in contact with heated carbon. Carbonic oxide and hydrogen gases were thereupon developed, which in their formation absorbed or rendered latent a very large amount of heat, and this heat was reproduced in the furnace when the gas raised from the decomposition of the carbonic oxide and hydrogen met with heated oxygen in combustion. Therefore the introduction of the vapour or water at the foot of the gas producer resulted in simply a transportation of heat from the point in the producer where it was not wanted, to the furnace where it was wanted. There was no creating heat in it, nor could direct advantage be claimed beyond that of carrying the heat from one point to another. There was, however, an incidental advantage in the admission of water or steam, in that it kept down the temperature of the fire-grate and prevented the brickwork being injuriously acted upon. He had for the first time seen the modification of the regenerative furnace to which Herr Liegel's name was attached. Many years ago he tried to construct gas producers with an accumulation of heat at the bottom to render the slag fluid, in order that it might run off instead of being dragged out of the bars, and if this could be practically accomplished, a very great gain would, no doubt, be effected; because the clinkering of the bars not only involved a considerable expenditure of labour, but much waste of fuel which must necessarily be dragged out with the clinker. The great difficulty which he experienced, however, was that the clinker would not melt under all circumstances. Sometimes it would, if it happened to be of a fusible composition; but in dealing with other descriptions of fuel the clinker would not melt, and instead of flowing at the bottom, it only clogged up the producer. He should be much interested to hear of the success of the proposed furnace in this respect. In conclusion, he could only thank the President for the opportunity he had given

him of expressing his views on this subject, and the pleasure he felt in seeing that the regenerative system was at last finding favour with gas engineers.

Mr. J. West (Maidstone) said the first time the importance of this subject was impressed upon his mind was when the members of the Association visited the Paris Gas-Works. He then came to the conclusion that the system of heating retorts there adopted was in principle the proper one; but he was not aware until now that Dr. Siemens was the prime mover and arranger of the system. He was, however, glad to inform him that he had certainly set his (Mr. West's) mind upon it; and seeing that he had not himself time to go in to the matter, he tried to find some one in England who had some experience of the principle, not being aware at the time that Dr. Siemens had arranged the retort furnaces in Paris. Knowing that they should at some future time erect a new retort-house at Maidstone, he was very anxious to obtain the assistance of some one who had a knowledge of the working of the principle, and he came across Mr. Stevenson, who was acting on behalf of Herr Liegel. He talked the matter over with him, and the result was that his Company arranged for a few of their new retort-settings to be erected upon that plan. They had intended to make a complete experiment, and to lay the results before this meeting, but they found it impossible to get anything done in time. He further stated that after he had made a start and arranged with Mr. Stevenson, he found that Mr. Livesey was working in the same direction. He had also another plan which he intended to work side by side with Liegel's system, one which was a combination of two or three of these furnaces which Mr. Livesey and others had arranged, for the object of gas managers should be to get at the best possible plan. He did not care whether it was Siemens's, Liegel's, Livesey's, Somerville's, or whose it was; what they wanted, first of all, was to satisfy themselves that the principle was a correct one, and of this he thought there could be no doubt. He was firmly convinced there was saving of fuel, but he did not attach so much importance to this as he did to the fact of regular heat being applied to the retorts, because in this way they could obtain a larger volume of gas than they could at present. They were all aware of the great loss of volume and illuminating power under the old system, where they had to empty the furnaces, during which time the cold air was rushing through them. Then they had to be heated again from the sides of the furnace, and the heat had to be transmitted from the hot furnaces to the cold coke. Now in any regenerative system the coke was left in a mass for months. In the case that had been mentioned in the first paper the furnace was not emptied for three months, during the whole of which time there was a constant and regular heat, that was to say, if the bottom slit of the furnace was attended to in a proper manner. As to the objection which Dr. Siemens had urged, that it might not be possible to run the slag off from the bottom of Liegel's furnace, he could only say that he had a difficulty in preventing the running down of the bricks; there was no doubt about the slag. The difficulty was to get a material to stand the intense heat of the bottom of the furnace. They had only put the furnace to work about a fortnight previously, and they had been in actual working about eight days, during which time, although they had not had any figures prepared, he had seen enough to convince him that it would be the system of the future. The men took well to the system, and although it had only been started a few days they were already up to the regular make of 8000 feet per mouthpiece; and he anticipated in a short time they would go on increasing, because they all knew that retorts only lighted a few days could not be expected to produce so much gas as those which had been alight six months. He was very desirous that the whole system should be thoroughly gone into. It was important that it should not be left in the hands of any single individual, and he would suggest that the Association should inaugurate and adopt some system whereby a few scientific men might be brought together who would fully investigate a system of this kind, or any system which was worthy of consideration. He himself had not the time to go into the experiments in the way they should be gone into; and, therefore, he thought there should be some gentlemen appointed who should go down to Maidstone, where they would have liberty to do as they liked, and test this system when it was ready. What they wanted to know was that they had the best furnace, which would produce the best results with the least expenditure of capital. His own impression, when he was in Paris, was that the system was a good one, but that the paraphernalia in connection with it was too elaborate, and that it might perhaps be worked out in a more simple way. What they wanted to know was, whether it would be worth while to spend the extra money in producing probably better results. This would be a matter of calculation; but he was firmly convinced that good results would arise from the system.

Mr. W. J. Warner (South Shields) thought this matter had really been carried beyond the experimental stage. It was no new system, for he remembered having seen it in the Birmingham works many years ago, although it was not so successful as to warrant its continuance. But that was only with reference to gas-works; its application to glass-works was almost universal, and on the Continent it was being worked constantly. Only a few days previously he passed through some enormous plate-glass works on the Tyne, where the system was going to be thoroughly adopted, and he might tell them what was said by Mr. Charles Mark Palmer, on visiting his works. He said, "What! you use coke furnaces! You are 20 years behind the times." He (Mr. Warner) thought there could be very few experiments required to confirm the economy of regenerator furnaces, as had been proved on the Continent, where so much attention was paid to the subject of fuel for furnaces.

Mr. G. Livesey (London) said he regretted he had not lately been able to give so much attention to this interesting work as he should have liked, from being occupied in other ways. The Siemens furnace was universally known, and it was thus hardly necessary to make special mention of Dr. Siemens's name, as every one knew it. The different applications of the principle were for them to carry out. There had not been much done in England certainly with regard to the heating of gas-retorts on the Siemens plan, but what he saw at one of the Paris works some years ago convinced him that it was the right system, and ever since he had been thinking of it. A year or two ago, at the South Metropolitan Gas-Works, they began to make experiments, but difficulties arose because the circumstances varied, and it was therefore not practicable to copy exactly any given system; it had to be adopted to suit special circumstances. Some 12 or 15 years ago Mr. Frank Clarke Hills, whose name was well known in connection with gas-works, gave considerable attention to the utilization of waste heat, and patented a plan for making use of it to heat the air that fed the ordinary furnace. He placed in the flue, under the bottom retort, a cast-iron pipe 9 inches by 4½ inches, which went the whole length of the setting. Air that entered at the north end he made to travel to the south end to feed the south furnace; and for the other side, the air entered at the south end, travelled to the north end, and fed the north furnace. The result of heating the air was remarkable, and showed there was much to be gained by it; but they were obliged to give up this plan of Mr. Hills's, because it was too good—it melted everything; it melted the bars completely. Then an attempt was made, both at their works and at the Chartered Company's works, to do without bars, and to have brickwork only; but that melted in the same way—everything was carried away by the immense heat. This showed the enormous loss that was being sustained by the heat that escaped after it had done its work in the ordinary settings. Now, applying this to the Siemens principle, he thought they had a process which would result in a great benefit. Dr. Siemens spoke about the percentage of saving, but he (Mr. Livesey) would remind him that at present the application of his furnace in England was in its infancy; it was not yet complete and perfect. For instance, with regard to the settings, to which his brother had referred, there was one great defect, that the hot air flues were of brick underneath the flue of the bottom retort, and it was impossible to keep brickwork tight. He was quite satisfied that the cold air was being drawn into the retort flues, and only a portion of it was heated and reached the combustion chamber above the furnace. A considerable proportion he was satisfied was sucked through into the ordinary flue, and carried away up the shaft, thus having a detrimental effect in two ways. The idea which led them to adopt the second plan was this: They noticed that in the stage house, where the regenerative furnace was placed, there was an enormous heat radiated from the furnace itself, and the idea at once occurred: "Here is a great loss of heat through the brickwork; cannot we adopt the Siemens system in the setting itself?" He had no doubt the plan would be somewhat modified, but so far it seemed to have a beneficial effect. As his brother had explained, they had a deep furnace, and supplied the hot air above the fuel, which was not dealt with so well as it would be when they had iron tubes for heating it, and they also prevented clinkering by means of the steam at the bottom, which was a great point to

have accomplished. One had only to go into the archway underneath, and look up into the furnace, to see that there was no intense heat there. The steam by its decomposition simply transferred the heat from where it was not wanted to where it was wanted, and there was no trouble whatever with the clinkering. This principle carried out further would, he believed, be found very beneficial. He quite agreed with what Dr. Siemens said about carrying out the principle in its entirety—namely, reversing the current; but there was great difficulty in applying this to retort-settings—there was not room for the chambers for heating the air. They were at present content with endeavouring to get the proper amount of heated air, and he thought they would be able to obtain a sufficient amount of hot air from the waste heat in the flues. He intended in future to have the main flue under the setting, instead of on the top of it, by passing the air-tube through this flue where the heat had done its work as far as the retort-setting was concerned. By this means they should get the air heated to a sufficient extent to accomplish all they required without the reversing chamber. He was satisfied that in England they were behind the Continent in this matter, possibly because fuel was so cheap they had been wasteful and extravagant with it. He did not feel that the gasmen of England would be doing their duty unless they pursued this object farther, and he had no doubt they would be rewarded by success.

Mr. C. R. Mead (Sutton) said that the general public gave gasmen the credit of being very much behind the times. Mr. Warner told them they were 20 years behind; but he (Mr. Mead) was afraid they were 25 years behind, for it was just 25 years since he had had the pleasure of testing one of Dr. Siemens's regenerating furnaces. The furnace he had put up did not require more room in the retort-house than the present bench of retorts, except it required more depth. In that case the furnace gases were turned through two flues under the ordinary settings. The flues were built with ollow walls—that was simply bricks laid loosely in—with apertures between the bricks, so that the furnace gas, after having passed to the retort ovens, passed through these hollow walls to get to the chimney. When the bricks on one flue became thoroughly heated, a valve at the back of the flue was shifted, and this turned the air that went to supply the furnaces through the flue containing the hot bricks. There was no question in the world that the saving in heat was enormous, and the only reason why it did not succeed in the small works where he had tried it was, that the men who had charge of the work, and ought to have reversed the valves, neglected to do so. He wished to impress on those who spoke of its not being practical in England, on account of the room it occupied, that it really occupied no more room in the retort-house than ordinary settings. The whole of the regenerative furnaces and flues might be placed on the ordinary settings, and required no more length than was used now. That the system would become universal he had no doubt, though he had very great doubt that his friend Dr. Siemens would get the benefit of it.

Mr. S. Hunter (Salford) said he thought it very desirable that a system of this kind should be tested; but as for adopting it in works having an underground arrangement simply consisting of an opening in the floor, and expecting men to go into the chamber, where an intense heat must prevail, it would probably result in failure. Perhaps they might have some information as to what class of works should turn their attention to the adoption of this method. He saw no difficulty about it in large works where they could apply a stage floor, where there was plenty of height, and a space beneath the floor; but he thought there would be great difficulty in small works.

Mr. A. F. Wilson (London) said that his experience with reference to the adoption of this apparatus in a small works was this: Some few years ago his attention was directed to the subject, and he had thought of it a great deal since. Three years ago a furnace was put up in some works he was in charge of, and it was very successful. The setting in these works was the ordinary setting; there was nothing underground, but they took out the middle retort, and formed a deep furnace, the form of which was very much like diagram Fig. 2. This was so successful that they at once adopted it to eight or ten furnaces, and after three years experience the results were so satisfactory that he should have no hesitation in recommending its adoption in even the smallest works. It was a mere question of designing the retort-bench, if a new one were being built; but where the benches were already built they could be converted by withdrawing the middle retort. On the question of wear and tear, he thought six retorts in an oven more economical than seven. They made a chamber for the combustion of the gases in the centre of the furnace, and built a deep furnace with two doors. This was practically a regenerative furnace. The works he referred to were those at Aldershot.

Mr. Denny Lane (Cork) said he was very glad that the honour of this improved furnace had been restored to the original inventor, Dr. Siemens, for he feared, when he heard the names of Liegel and others connected with an invention which was solely and indisputably that of Dr. Siemens, that he would be denied the credit of it. To put the matter in a practical point of view: What gas managers were suffering from at present was the too great ability of Dr. Siemens; because if he were not a man of such great powers that he had managed to apply scientific principles to so many practical objects—if his attention had not been diverted by his great improvements in the manufacture of steel, by the great electrical achievements by which he had spanned the oceans with electric wires, and by so many other subjects—and had paid a little more attention to the special application of the regenerative system to gas-works, the whole question would have been solved long and long ago. They were suffering from an *embarras de richesse* of Dr. Siemens's mind; but if at any time his learned friend could contrive to limit his genius, and, like Burke, give up to gas-works what was intended for mankind, the whole question, as far as gas managers were concerned, would be exhausted.

Mr. W. Carr (Halifax) said they were very much indebted to the authors of the papers for coming forward with their very limited experience of the furnaces they had been trying. When he was in Paris two years ago he, like Mr. West, was struck with the effect of the regenerative furnaces there, and felt satisfied that it was a step in the right direction, and one which ought to have been taken long ago. The difficulty he had always had to contend with, for he had aimed at getting the highest heats possible, had always been the destructiveness of the furnaces in which great heat was obtained. As the furnace had to be placed in close proximity to the retorts themselves, when the furnace went the retort-setting went with it, and great damage was done, and great wear and tear was occasioned, which meant a loss of money and not an economical system of working. He had tried in various ways to obviate this difficulty, but the only real and certain system of getting rid of the objectionable feature was not to work at such high heats, which, to his mind, meant a loss of profit at the end of the year. But the way out of the difficulty seemed to him to be perfectly clear when he saw the furnaces in Paris. From the discussion that had taken place, he thought there was no doubt about who was the author and inventor of the principle; but Dr. Siemens would allow that other people had tried to modify his arrangement, and to make it applicable to the circumstances of those people to whom the arrangement which obtained in Paris was not quite so convenient as it might be. Dr. Siemens said he had himself tried various systems from time to time, and all that was claimed by the authors of the papers for the different names which were mentioned, was that the arrangements described were not inventions, but applications of the Siemens principle. He was somewhat in doubt as to the exact point where Mr. Mead left them when he closed his remarks. He said that he had tried this system 25 years ago, and found only one fault in connection with it—that the men would not change the valves at the right time. He (Mr. Carr) did not know whether Mr. Mead had come to the conclusion that the progress of evolution had gone on at such a rapid rate that men were now fit to be entrusted with this duty, but it was a great pity that some effort was not made at the time to obtain the help of some men who would have attended better to the regulation of the valves. For their sakes it was a pity, as Mr. Denny Lane had suggested, that Dr. Siemens had not devoted more attention to the subject of gas furnaces; but, as far as the community at large were concerned, there was no doubt the work he had done in the scientific world had been of gigantic benefit, and they were much honoured by having him amongst them that day, and hearing the very clear and lucid speech he had made, and the forcible manner in which he had put some of the fundamental principles of the regenerative furnace before them. Personally he felt very grateful to him, and he had no doubt, from the reception his name had met with, that the feeling was expressed by every member present. With regard to the question of regenerative furnaces, he should endeavour to do something to further the object they all had in view, and he hoped that it would not be long before they had such a system of regenerative furnaces at work that they might be able to attain something like a uniform temperature in carbonizing, and when that came they would have advanced a

considerable stage towards a more profitable and scientific application of their business.

Mr. G. Anderson (London) said this was one of the things he had something to do with. He had heard a good deal about these regenerative furnaces, but sometimes their friends were in a considerable difficulty from not having good accommodation. In some places it was not possible to go down a couple of feet below the floor without getting into water, which was a bad way of getting steam. However, he could deduce from what he had heard that there was great advantage from these furnaces if properly applied. One thing which struck him in reading about them, which he had not heard answered by the readers of the papers or even by Dr. Siemens, was that all these regenerative furnaces were argued from the principle that a saving was effected because the carbonic oxide was converted into carbonic acid. But supposing all the fuel was converted into carbonic acid, without the secondary process would there be a saving of fuel? This was a question he should very much like Dr. Siemens to answer. The reader of the first paper said there must be 3 or 4 feet in depth of fuel, or carbonic oxide could not be made. Granting all this, if he had only 18 inches of fuel with which he could heat retorts very well, and which produced carbonic acid, where was the advantage of first producing carbonic oxide, and then giving it another atom of oxygen to make carbonic acid? No doubt the doing away with clinkering of the fires would be a grand thing, for the opening of the furnace for a quarter of an hour or twenty minutes to take off the clinkers, while large volumes of cold air were rushing through the furnace and cracking the retorts, was a thing which would be avoided with these furnaces. Another question he should like to ask was this: It appeared to him that an inferior fuel might be used with these furnaces; but could breeze be used, or breeze and coke, instead of all coke, as at present? If the full calorific value could be obtained out of the breeze it would be a considerable advantage, because it did not fetch the price it ought to, considering its calorific value. These were questions which those who were trying the furnaces would be able to answer when they had tried them further. He had no doubt they should have these regenerative furnaces soon in use, and he had hoped that he and his friend Mr. Lane might have introduced them at Cork; but there they had a solid limestone foundation, and if they had to get down a certain depth it meant excavating in solid rock.

The President said it was not necessary to ask Dr. Siemens to reply to the inquiry of Mr. G. Anderson, because that gentleman had apparently misapprehended the object of these furnaces, which was, not the production but the reduction of the carbonic acid. They might congratulate themselves that this question, although of very recent importation, had already taken firm root amongst them; and he hoped the result would soon be made apparent in the wiping off of that reproach to which Mr. Livesey had referred; and the placing themselves upon a level, at the very least, with continental practice.

Mr. F. Livesey, in reply, said he quite agreed with the sentiment expressed with reference to Dr. Siemens. There was no doubt whatever that to him belonged all the credit of the invention of the regenerative furnaces. Dr. Siemens said that they only effected a saving of 25 per cent., whereas they should have more; but he (Mr. Livesey) must remind them that the arrangements he described were not perfect by any means, and no one was more aware of this than himself. For instance, in this arrangement the air was heated underneath the bottom retort, which was generally the coolest one in the bench, and, of course, if heated under there it might take away heat from it, so cooling the coolest part of the retort-setting; but notwithstanding this they were able to keep the bottom retort sufficiently hot to carbonize the coals, and also to effect a saving of 25 per cent. of fuel. With regard to clinkering, in the second arrangement described they found there was no hard clinker formed, and after the furnace had been at work for three months it was not burnt away at all; the only clinker formed being from the coke, which was very friable, and could be pricked out with an ordinary tool by a man attending two or three times a day. There was no large hard lump of clinker as in ordinary furnaces. The steam kept the bottom of the furnace very cool, and the only portions at all burnt were the corners of the bricks which formed the steps. In future it would be put in as a smooth surface instead of the bricks being stepped back. It would be much better if the air could be heated by the waste heat, instead of taking it away from the retort-setting. Dr. Siemens had very properly corrected him in saying that the water improved the draught. He meant to say that steam would improve the draught, not water. The water would only decrease the temperature at the grate, and give combustion higher up, where it was more needed. Mr. Hunter referred to the size of the works where these furnaces could be used, but he did not think this had anything to do with the adoption of the plan. It was, perhaps, more easily worked out in a stage retort-house, although they were now trying it on the floor. All that was necessary was to make a few steps down in front of the furnace, so as to get it a little deeper. If the retort-settings were a little higher there would then be no necessity to do this. In reply to Mr. Anderson as to the use of breeze, he might say they were able to use a small proportion, but it would be impossible to get any air through a mass of breeze 3 feet thick and 4 or 5 feet wide.

Mr. Stevenson said there seemed to be a little misapprehension on the part of Mr. Anderson as to the action of these furnaces. The furnace was designed for the purpose of preventing the primary formation of carbonic acid in any quantity. There was a primary formation of carbonic acid just at the lower part of the furnace, but the gases of combustion passed through so great a depth of fuel in the body of the furnace, that in coming in contact with the carbon of the fuel they became reduced to carbonic oxide—the coke was partially consumed, and the carbonic acid became reduced. The reason of the saving was explained in the paper, that the gaseous fuel could be so much more intimately mingled with the atmospheric air necessary for its consumption than solid fuel could; and, therefore, the quantity of air necessary for the complete combustion of gaseous fuel would be very much nearer the theoretical quantity than that required for the combustion of coke or coal. Breeze could be used in the Liegel furnace, and in any regenerative furnace, in certain quantities. He would not say they could use all that was produced, but very little would be produced. There seemed to be some idea that there was an attempt on the part of some of these German gas managers to wrest from Dr. Siemens the credit of being the inventor of the regenerative principle, but this was not the case at all. It was only just to say on their behalf that there was no question whatever that Dr. Siemens was the inventor; in fact, as had been stated, it received its name from him. But a man like Herr Liegel was entitled to the full credit of having worked out an arrangement like the one described, even if it were like something Dr. Siemens had worked out in early days, and he (Mr. Stevenson) was quite convinced that it had been worked out almost as a new invention. One of the obstacles to the introduction of this principle into small gas-works would be that in any form whatever the regenerative furnace cost more than the ordinary one, and some of the few questions put to him when inquiries were made about it was, what would be the proportionate cost. This he was not prepared at present to state, or he should have mentioned it in his paper; but it was so far reasonable that in a comparatively short time the furnace would repay its extra cost. It could be applied in any sized works, and the majority of those using it in Germany were very small works. Those employing Oechelhäuser's were considerably larger. He did not know any besides the Paris Gas-Works, which were very large, that used the complete Siemens furnace. Mr. George Livesey said the principle was still in its experimental stage, but he must differ from him as to that with regard to the Liegel furnace. It might not be complete, but it had been worked out, and had been used in its present form for several years. It might be experimental in England to this extent, that if new works were being constructed, the engineer, as he had had no experience of it, might hesitate to put it in at first starting, lest from the inexperience of workmen some failure might result; but this would not be on account of the furnace itself being in an experimental condition.

(V.)

THE CONSTRUCTION OF GASHOLDERS;

OR,

MODIFICATIONS AND IMPROVEMENTS IN GASHOLDERS AND THEIR GUIDE FRAMING FOR WITHSTANDING WIND PRESSURE WITH GREATER CERTAINTY, AND ESPECIALLY WITH REFERENCE TO THE PRACTICAL APPLICATION OF THE CENTRAL COLUMN PRINCIPLE OF GUIDING.

By Mr. G. Barker, of Birmingham.

The object of this paper is to elicit a practical discussion upon the best mode of guiding large gasholders, so as to successfully withstand the most severe wind pressure.

That a great difference exists in the opinions and practice of engineers, regarding the construction of gasholders and their guide framing, is evident from the paper read before this Association by Mr. Corbet Woodall in the year 1874,

from which, for the sake of connection, the first paragraph is reproduced. Mr. Woodall said: "In 1868 an interesting and valuable paper, followed by an equally interesting discussion, was contributed to this Association, on the subject of gasholders. When, at the request of our Secretary, I undertook to furnish a paper on the same subject, it was with the feeling that the discussion to which I have referred stopped far short of exhausting the interest of the questions then raised, and that the continuance of that diversity of opinion and practice among engineers, to which Mr. Anderson then referred, made the matter one worthy of renewed consideration."

This difference of opinion seems to have been evidenced in a still greater degree by the discussion following the paper read by Mr. Harry Edward Jones in this building, before the members of the Institution of Civil Engineers, in June, 1875—just five years ago—when, at the conclusion, the President (Mr. Harrison) said: "The paper has at any rate elicited the fact that gas manufacturers are not unanimous. I hope their differences will result in an active competition to improve the process of manufacture, and if this shall be accomplished at a diminished cost they will receive the hearty thanks of the country."

In the discussion on the last-named paper, the most radical differences of opinion were expressed regarding the form, construction, and strength of gasholder framework, and the economical distribution of metal in such framework. That great divergences of opinion still exist, is clearly proved by the variety of designs and strengths of structures recently built, and the stability of these structures varies as much as their outward appearance. The author thinks there are three causes which bring about this state of things. The first, and by far the least, is the uncertain data regarding wind pressure; the second and chief cause is the great difficulty which exists in making any reliable calculations of the stability of the framework, because of its complicated form; and the third is the treacherous material used.

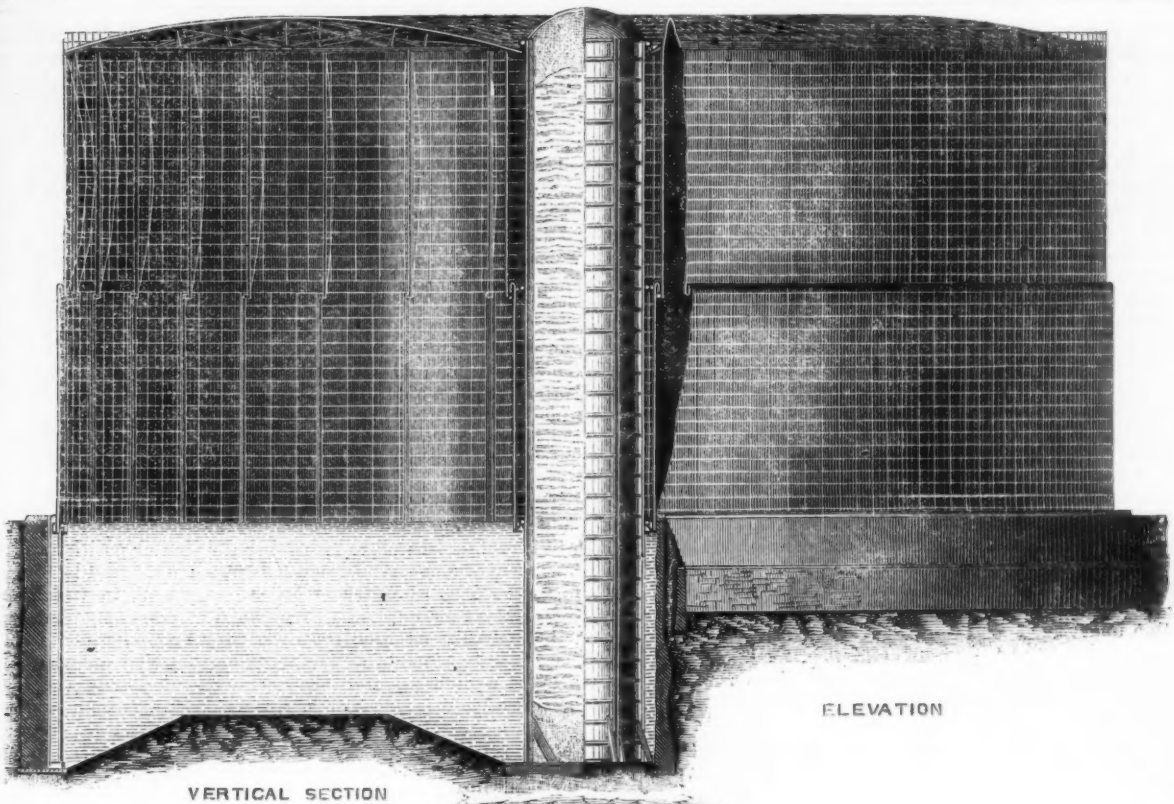
As regards the first uncertainty—viz., wind pressure—we have recently had our stock of data increased in connection with the Tay Bridge inquiry; but the evidence adduced tends rather to increase than otherwise the difficulty of arriving at a definite conclusion. For example, Sir George Airy, the Astronomer-Royal, said that the maximum wind pressure recorded at Greenwich was 40 lbs., and then the instrument gave way. If it had not given way, he believed it would have registered 50 lbs. pressure per square foot. He believed this was sometimes exceeded in Scotland, and it might reach from 50 lbs. to 100 lbs., especially in the Valley of the Tay, and that in some notes based upon rough calculations, he had put down 120 lbs. to the square foot as what should be provided against in that particular locality. Mr. Robert Henry Scott, Secretary of the Meteorological Office, said he agreed with the opinion of the Astronomer-Royal that the wind in Scotland might rise to a pressure of 50 lbs. per square foot. On the other hand, Dr. Pole thought that 20 lbs. per square foot was sufficient allowance for the wind in the case of the Tay Bridge; but Dr. Pole said, under examination by Mr. Bidder, that in England there might occur a pressure of from 40 lbs. to 50 lbs. on the anemometer, and probably more in Scotland. The late Professor Rankin gives 55 lbs. as a probable wind pressure, and it is said that French engineers allow for the same pressure in designing bridges. In gasholder framework, the author has always taken 56 lbs. (half a hundredweight) as the maximum wind pressure.

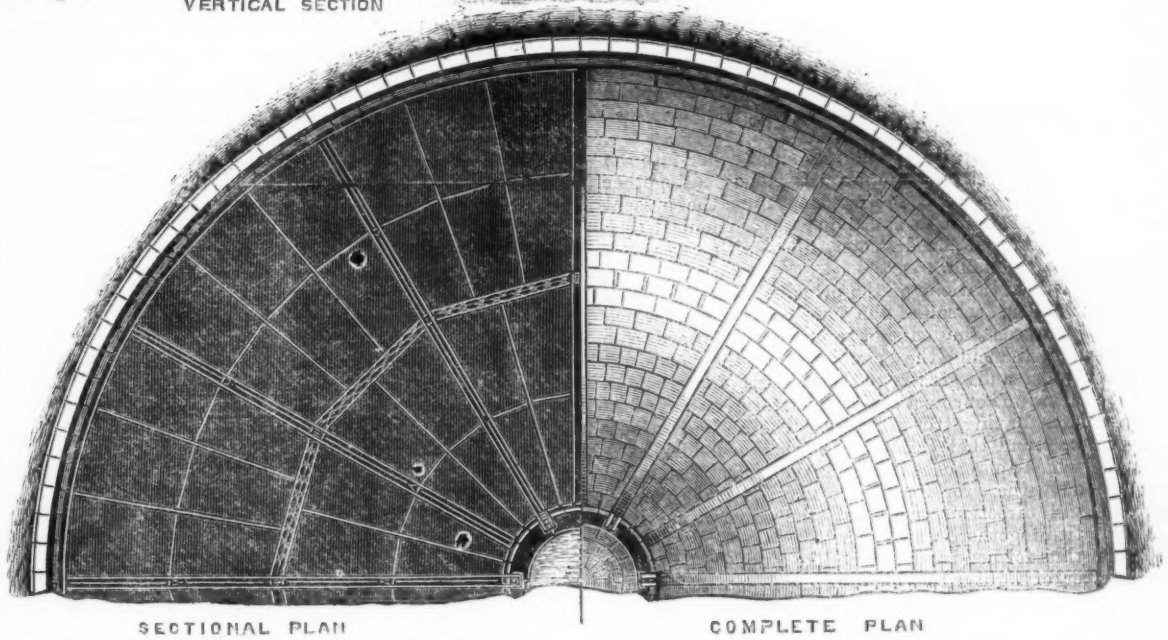
With reference to the second point—viz., the complicated nature of the present plan of constructing gasholder framework, and the consequent difficulty of calculating its stability—the data afforded by the Tay Bridge inquiry is again most valuable, because the piers were very similar to gasholder framing; *i.e.*, they were composed of cast-iron columns and wrought-iron bracing, the base of the six columns forming an oblong hexagon, or a similar base to that of a gasholder surrounded by a framework. A structure of this description requires difficult and tedious calculations to ascertain the strains upon the various members, and after all there are uncertainties in such structures, which are not common to those of more simple design. The material also of the Tay Bridge piers was of a similar kind to that now used in gasholder framing, and the author is of opinion that, had the strains been definitely ascertained, cast iron was not commendable in such a position where it was subject to suddenly alternating strains and shocks. His letters published in *Engineering* on this subject in 1876, and in January of this year, immediately after the fall of the Tay Bridge, giving the results of long experience in cast iron, show how little reliance can be placed on that metal when subjected to tension or concussion. Cast iron is admittedly a suitable and economical metal, for the members of structures subjected to compressive strains *only*. The tensile strength of sound cast iron as used in this country varies from 7 to 14 tons per square inch, with exceptional specimens giving as high a result in the testing machine as 18 and 19 tons per square inch, and registering as low as 4 tons per square inch, the appearance of the sections of such weak metal suggesting nothing very exceptional to the eye in the broken fracture. The strength of cast iron under compression probably varies from five to nine times its tensile strength, and taking the lowest tensile strength before mentioned, we have a material capable of bearing 20 tons per square inch in compression, and therefore suitable for *simple* compression. In columns such as are used around gasholders, where any side may at any moment be thrown into tension by a sudden gust of wind, cast iron cannot be considered the most suitable material, and ought not to be used unless the margin of strength be very great. In the author's letter to *Engineering* of January last, before referred to, 2 tons per square inch was mentioned as the most which can be relied upon in such positions as the piers of a bridge, and even this low estimate would only apply in the place of such cast iron as would give an average strength in tension of, say, 11 tons per square inch. In the more ordinary classes of cast iron, such as that used in general foundry work, it would not be safe to count upon more than from 1 ton to 1½ tons in tension.

In gasholder framework the supports, whether stanchions or columns, are liable to the strains such as have been described—*i.e.*, in modern structures where the tops are supposed to be effectively connected together by girders. For example, supposing the strains to be efficiently transmitted by these girders, then it will be clear that any column or stanchion may have any part of its circumference or sides brought into either tension or compression, and a steady force applied against any column from *inside* the circle would draw all the columns down, supposing that the tension girders did not give way at their junctions, for the ring of girders has a tendency to straighten itself into two direct lines from the point of strain to the point of greatest resistance. The connecting girders may either be considered as acting like the links of a chain—simply connecting together the tops of the upright supports—or as a rigid ring or arch of sufficient stiffness to keep its polygon form. Modern practice in the construction of such rings, is to connect the outer frame of the holder, at the top, by wrought-iron lattice girders, the ends of which are butted together behind the entablatures, and firmly connected by top and bottom fish-plates, of sufficient section to make the junctions the stiffest part of the ring. Thus in a 200-feet holder we have a 20-sided figure, maintained in shape by, first, the stability of each column, due to the sum of its weight, and the foundations grasped by its holding-down bolts and foundation plates; and, secondly, by the 12-inch wide and 4-feet deep girders which form the rings.

Now, it is very easy to ascertain the stability due to the weight of a column added to any base grasped by the foundation bolts, but the additional resistance to overturning due to the 12-inch rings of girders is generally a most uncertain element in the calculation; and it is to be feared it is often greatly over-estimated. Let it be supposed that the holder is driven against any of the columns as ordinarily placed, and it will be at once obvious that the girders are the wrong way to resist a strain—viz., with the edges of the flanges to sustain the strains; indeed, the mass of metal is concentrated at the neutral axis of the girder, and it is comparatively ineffective under such conditions. Probably this error has been fallen into in the first place to give a better appearance, and has with very few exceptions been followed like a sheep's track ever since; the main consideration of maintaining the shape of the framework at the top, as the tank so perfectly does at the bottom, having been lost sight of. Really what is required at the top is another rigid ring like the tank itself, which would resist any tendency to alteration from its original shape. The girders being merely turned on their side has the effect of producing a ring 4 feet wide, bounded on both its edges by a 12-inch plate and two angle-irons, which are properly placed at the farthest position from the neutral axis of the beam, when resisting a force applied as in the previous case. This simple modification would increase the stiffness of the ring by about twenty times its previous strength—*i.e.*, it would have so much greater power of resistance to alteration in its original shape, and yet the same strength in direct tension, and would consequently tend to ensure all the columns acting in unison.

It has been suggested in favour of the old plan that the curb of the gasholder itself would help to resist any ten-





dency the guide-frame might have to collapse; but though this might, to some extent, be true, it seems to the author a doubtful policy to calculate upon the gasholder sustaining its own guide-frame, when the guide-frame is designed to steady the gasholder.

The cross bracing-rods between the columns are another element of uncertainty, and the author believes that no one has yet laid down any rule respecting the assistance they afford. They are therefore generally thrown in, and it is considered that they can at least do no harm if they do no good; but perhaps we may be favoured with recent and reliable data regarding this point. To present to the eye an *appearance* of strength, which may or may not exist in reality, is a condition of things which leads to waste of material, or else to a false sense of security. The statement made, I believe, by a very high authority—Mr. Hawksley—that where the columns are properly tied at the top, the total strength will be the stability of one support multiplied by the whole number, is, no doubt, a safe conclusion. But there are those who advocate just the opposite theory—viz., that the framework may be considered a solid ring, or its equivalent, with a base equal to the whole diameter of the holder. The author believes, and no doubt many gentlemen will agree with him, that the truth lies between these views; but *where*, is the great question. The present form of the connecting girders is such that it is quite impossible to do more than say that they assist the columns or stanchions to some extent. The author believes that links pivoted at each column would be in many respects better than stiff joints, unless the stiffness be sufficient to keep the upper ring in its original shape, because the intermediate condition between a rigid ring and a moveable joint would, in case of a breaking strain, probably result in snapping off the girders sideways, close to their junctions with the uprights, and thus their intended utility as tensional connecting members would be destroyed.

The author has now the pleasure of placing before the meeting some suggestions for guiding gasholders by a central column instead of by outside framework.

The central principle, though known many years ago, only occurs, I believe, once in the Patent Records. It is there mentioned, and illustrated in a very crude form, as a mast guiding a small holder intended for producing gas from petroleum. This small holder has its top corner or curb

rounded similar to the holders that have been built at Beckton. The specification is dated 1872, and is in the joint names of T. A. Howland and C. G. M'Knight.

Gasholders on the central principle were constructed more than 20 years ago, by Messrs. Thomas Piggott and Co., for Sweden. They were small one-lift holders, guided at the centre by a wood post or mast, which was greased to allow the holder to slip up and down easily. A central holder was erected at the Horseferry Road works some 20 years ago, and is said to have failed because it was unsteady. About this time also, Messrs. Piggott commenced to make a gasholder which was to have been guided by a central column; but the idea was given up, and the holder was completed with outside guides. A length of the central column still stands in the makers yard at Birmingham. It is 8 feet long by 4 feet external diameter, and is provided with internal flanges for bolting the various lengths together. It is not improbable that the unsteadiness of the holder at Horseferry Road led to the abandonment of the one commenced by Messrs. Piggott.

There is also in St. Petersburg a two-lift gasholder 130 feet in diameter, guided by a central column, which is still working satisfactorily; but this holder is not subjected to wind pressure, as it is protected by a strong brick building. The central column is composed of cast-iron plates lightened out, and has doubtless been used for the twofold purpose of supporting the rafters of the outer building, and of guiding the holder, the latter appearing to be quite secondary. A column under such conditions can have but very little to do. Messrs. Laidlaw and Son, of Glasgow, made this holder. There may have been others tried, and the author will be pleased if his paper should have the effect of bringing them forward for discussion.

The guiding columns on the central principle are so simple in construction that a practical man with a 2-foot rule may ascertain in a few minutes their resistance to overturning. The central column is composed principally of earthwork excavated out of the tank, and surrounded by a suitable casing or casings, made from the most appropriate materials at hand. The author's first idea was to concentrate at the centre of the tank one-third of the present outside columns, so as to tie them together by direct cross girders at the top, and so produce a stiff support; but, in going farther into the subject, it was manifest that a number of rings tied together at the centre, though a great improvement upon the present system, would neither be so stable nor so economical as a single tube of considerable diameter, filled with earthwork excavated out of the tank.

It will be noticed that one of the principal features of this system is the arched instead of the dome form of roof, which falls partly towards the outside, and partly towards the central column, reducing the span by more than one-half. This form of roof adds greatly to the stiffness of the holder, and at the same time effects a saving in material as compared with gasholders having trussed roofs. The author believes also it will be found that this plan allows of a holder being constructed which approaches nearer to the correct theoretical form than any other, for its outside may be made equally flexible in all directions, while at the same time it is thoroughly tied together in every part.

A holder thus formed is very much like an umbrella, with a large number of light ribs which spring from the cup and form a parabolic arch at the top, finally resting against the central tube, or turning down both sides alike. The general shape is maintained by diagonal truss rods, which radiate either to the centre or side of the inner tube, and tie the whole together. This mode of construction is very clearly illustrated by a modern bicycle wheel, with its large number of very light radial rods. All the ribs and a part of the diagonals concentrate at the inner curb, to stiffen the ring for receiving the roller carriage to guide the holder. No truss-rods are used in the roof, because the small span of the arch and the number of the ribs, with the diagonal cross ties, render it quite self-supporting when grounded.

It should be carefully noted that there is no existing system of either trussed or untrussed roofs which cannot be used with equal facility; indeed, whichever kind of roof is preferred, the first cost will be reduced by the adoption of the central system. The surface exposed to the wind is also less, because when the roof has risen towards the centre of the arch, it then commences to fall towards the central column. This arched form does not lessen the capacity of the holder for storing gas, but merely removes a totally useless space, as the gas which accumulates at that part cannot be drawn out. The centre of gravity in these holders will also be found lower than in any other existing plan, because of the lightness of the roof ribs, roller carriages, outer curb, &c.

The internal pressure of the gas would be slightly reduced by this proposed mode of construction, because of the reduced weight of the holder. This is probably not advisable, because the inner pressure should, no doubt, exceed the greatest outside pressure of wind, for the purpose of preventing any liability of the plates to buckle inwards, or any vibrations of the plates, and this remark especially applies to holders with untrussed roofs. It would certainly be very dangerous to reduce the internal pressure too much; but considering the tendency of holders to tipple over, any extra weight required might with great advantage be added at the base of the upper lift, which is practically the foundation of the side walls, and this part is generally out of the water. The tippling of a gasholder is, of course, a calamity, and ought to be most carefully guarded against. The author remembers some 20 years ago seeing a gasholder tipple; the bottom edge on one side lifting out of the water, and at the same time the escaping gas took fire. The night being dark, the effect of the flames was grand and impressive. Fortunately no lives were lost, but it was a sight not easily to be forgotten.

It may be objected that the water in the inner cup will be liable to freeze, and would be in an inaccessible position. It will therefore be well to remember the similar position of the inner cup of a central-column holder, when covered by hinged plates, to that of water in an ordinary well, in which the temperature does not vary much from winter to summer, and will generally be found a little over or under 50° Fahr., according to the depth. The inner cup freezing did certainly present a difficulty until last winter, but during the long hard frost which prevailed, the outside cistern which supplies the bath-room at the author's house became solid ice, and the supply had to be carried each morning from the pump. The temperature was most agreeable, being 16° higher than that previously used.

Reverting to the stability of columns, I would remind you that the stability of hollow columns increases as the squares of their diameters—this shows the advantage of large columns over small ones; but the stability of solid columns increases as the cubes of their diameters, which is a fact that has not been taken advantage of in the designing of gasholders. The results of a few experiments are given in the following tables:—

Experiments in Tilting Tubes.

Diameter of Tubes.	Length of Tubes.	Weight of Tubes.	Force required to pull over Empty.	Remarks.
Inches.	Inches.	Drams.	Grains.	
1	9	13	50	—
2	9	26	200	—
4	9	52	800	—

The same Tubes filled up with Sand.

Diameter of Tubes.	Length of Tubes.	Weight of Tubes.	Force required to pull it over Full.	Remarks.
Inches.	Inches.	Drams.	Grains.	
1	9	64	240	Rammed.
2	9	230	1,980	Do.
4	9	736	11,640	Not much rammed.

The tubes were all one length and one thickness.

It may now be instructive to compare the stability of an actual example of a modern outside guide-frame with a central column constructed in the way proposed by the author. Taking, then, a 200-feet gasholder with two lifts, or 80 feet high, surrounded by 20 columns or stanchions, each of which weighs, say, 20 tons, there would require a force of 7 tons at A, on the accompanying diagram (Fig. 1), to overturn one column—*i.e.*, after allowing that the foundation bolts grasp 12 feet cube of brickwork, or 1728 cubic feet each. Thus we get a total stability, supposing the whole of the columns to be brought into action, of $20 \times 7 = 140$ tons. But it must be remembered that before all these columns could be brought into action the side of the tank would probably be split, because one or more columns must be considerably bent *outwards* before the others would be brought into action at all, and thus there is always the tendency to split the tank directly below the foundation bolts. This, of course, will right itself when the pressure is removed which caused the split; but it must be placed amongst the weak points of the outside system, for it certainly is desirable that the tank walls should be as free as possible from strains. More formidable levers could scarcely be placed for destroying the tank than are these columns. It is

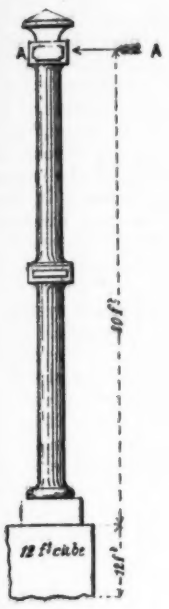


Fig. 1.

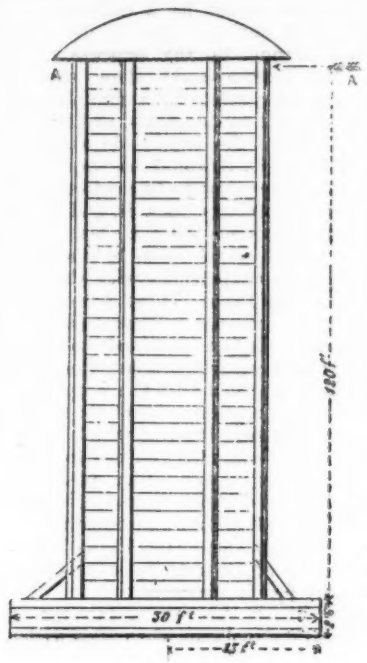


Fig. 2.

probably impossible for any one to say how much trouble in leakage has been caused from time to time in this way. The fact that the weight of the columns would close any crack when the tank is empty, rather increases the danger than otherwise. Annoyance under such conditions might continue a secret for a long time, and thus cause endless trouble and expense.

The central column shown in the sketch, Fig. 2, is composed of wrought-iron plates and rolled joists, 15 inches deep by 6 inches wide, and fished on the face with 6-inch channel irons, and also at each side of the web, thus forming the roller guides. These joists are stiffened sideways by 240 T-iron circular gusset ribs, all of which are bent to one block, and punched duplicate. The plates are placed inside the framework, with roughly-butted joints, double rivetted to the cross rings. There will thus be no impediment offered to the free settlement of the earthwork inside, and the ribs would always be accessible for examination. We will take this column as 20 feet in diameter and 120 feet high, with a 30-feet base. When filled up it would weigh with the casing about 2000 tons, and it would require a force of 250 tons acting in the direction of the arrow at A to turn it over. This gives 80 per cent. greater stability than in the case of all the 20 columns previously considered, with less than one-third the weight of metal contained in the outside framework.

As regards the tank, there would be just about the same amount of excavation in both cases, as the 20 recesses for the outside pillars would just about balance the amount of earth required to be excavated at the centre, for filling up the column. Lifting the earth into the column would cost rather less than to cart it away, especially in large towns. The erection, too, of the central column presents neither difficulty nor danger, and requires no scaffolding; the earth is filled in while the work proceeds, and thus there is always a solid footing for the men to work upon. Indeed, all practical men agree as to the ease with which this central column could be built.

Now with reference to guiding. The author here speaks with great diffidence, not because there are any doubts on his mind, but because the holder at Horseferry Road is said not to have been satisfactory, and the one commenced by Messrs. Piggott was discontinued, and mainly because the central system has not been fairly tried. We must not, however, forget that the screw propeller failed time after time, and a host of other important inventions have required several trials before they were successful. The holders which have been tried on the central principle seem to have been carried out in a very crude manner, and the author attributes their failure to their want of stability and imperfect details, such as guides, guide-rollers, &c. The roller carriages, as now proposed for the central system, are shown with triple rollers —viz., one front main roller, and two small side fraction rollers. When it is remembered how great the facilities are for erecting truly, and for readjusting the central column guides, as against outside guides, how easily fitted, and how little affected by contraction and expansion, the author believes that a central holder would ride quite as steadily as an outside one, and it would be readjusted with greater facility at the centre than at the side. Indeed, the whole success would depend, first, upon a perfectly stable column, which can certainly be obtained, and next upon the details of the guide-roller carriages, neither of which presents great difficulty to a practical engineer. Where land is scarce and dear, the central system will have the advantage of storing about 20 per cent. more gas than the same area of ground would do on the existing principle with outside guides.

Hitherto no mention has been made of economy—indeed, it has been purposely avoided, because it seemed desirable that the systems should be compared as regards safety and efficiency, altogether apart from cost. Yet economy is an important matter, and it is a considerable item in the present comparison. According to all the calculations made, it may be considered that two-thirds of the dead weight in metal will be saved, and this will be equally the case should the outside framework be reduced in weight; for when it is seen how cheaply stability may be obtained by this system of concentration, it will also be evident that whatever outside system may be adopted, the same strength can be given by concentration with about one-sixth of the same metal. The author is, however, quite content to place the figures at *one-third*, thus throwing in the extra margin of stability. Speaking roughly, but safely, the economy in gasholder construction will be about 20 per cent.—*i.e.*, taking the dead and floating ironwork together. Thus, a gasholder costing for ironwork £15,000 for the outside system, will only cost £12,000 for the central system; or one on the outside system costing £10,000, would be obtained for £8000 on the central system. These figures are fully borne out by actual tenders sent in by eminent firms.

The advantages claimed for the central system may be briefly summed up as follows:—

1. Stability can be obtained with *absolute certainty*.
2. Storeage capacity, per square foot of land, 20 *per cent.*
3. Economy in metal for guiding, *two-thirds*.
4. Centre of gravity of vessel, *lower*.
5. Strain on the tank walls, *none*.
6. First cost, 20 *per cent. less*.
7. Cost of tank, *equal* in both cases.

In conclusion, the author wishes it to be most clearly understood that the reference made to the present outside framework, and connecting guides especially, is not by way of instructing gas engineers, who have especially studied this subject, but purely for the purpose of eliciting a discussion as to what is the best modern practice in outside framework, as compared with the suggested central system.

Discussion.

Mr. Corbet Woodall said he had hoped that before the discussion on this paper had been taken they would have heard a description of the gasholder, on the same principle, designed by Mr. Wyatt for the Chartered Gas Company, for he felt they were very much at a loss in entering on the discussion without having that illustration before them. He believed Mr. Wyatt had given to the question of the central guide, as opposed to the outside framing, a large amount of attention, and had arrived at very much the same conclusion as Mr. Barker had done. The paper itself was admirably prepared, and the points were very clearly stated. He (Mr. Woodall) was pleased to hear the remarks made on the respective advantages of using wrought iron as opposed to cast iron in gasholder guide-framing, and there could be no doubt of the importance of this point, because of the extreme difficulty of satisfying themselves of the quality of the metal put into cast columns and stanchions; and also of satisfying themselves of the even division of the metal, especially in columns. It was, therefore, a very risky material to use. For instance, he heard from a gasholder maker a short time ago that one of a set of columns to be used for guiding a gasholder had been duly cast at the foundry, loaded on trucks, sent by rail somewhere in the South of England, unloaded and brought on to the works, and yet when being hoisted on to its place it absolutely dropped in two. One could realize such a circumstance without very much reflecting on those who had the passing of that column when delivered. On the other hand, with wrought iron, while it was equally easy to determine what should be, theoretically, the section of metal to bear the calculated strain *when* provided, there was far less occasion for anxiety as to its behaviour.

He did not quite catch whether Mr. Barker expressed an opinion on the desirability of placing connecting girders horizontally instead of vertically in connecting stanchions or columns. It seemed to him that when they had, as they had in many places in the country, the framings constructed and working quite satisfactorily without any girders at all in the sense usually employed—namely, to exercise an influence both as struts and ties—it was not of very much consequence how they lay. He thought it was not so much a question of appearance in the first place, as of greater economy in the material which resulted when they placed a girder on edge, in its legitimate position, rather than on its flat, where its own weight tended to deflect it, and so exercise an undue strain on the framing to which it was attached. With reference to the diagonal bracing, Mr. G. Livesey, in designing the enormous gasholder he was constructing at the South Metropolitan Company's works, had largely adopted the theory of the French engineers, who disregarded altogether the question of holding-down bolts, and treated the whole framing as one complete structure, and trusted to every portion of it contributing its share to the support of every other portion. From this point of view a more frequent and complete bracing was not only advisable, but absolutely necessary, and the idea of making a complete ring of framework of this kind seemed to have very much to recommend it. In a wrought-iron stanchion it appeared to him (Mr. Woodall) there was no difficulty in getting all the strength which could be required by any circumstances of wind or weight likely to be brought to bear on the gasholder, and such a frame did not involve much more expenditure of metal than was necessary in order to make the stanchions strong enough to support themselves. One point he should have liked more information upon, and that was how Mr. Barker proved the point claimed that there was, with the same area, a saving of 20 per cent. in the storeage capacity by the use of the central column.

Mr. George Livesey said he had only heard the last part of the paper, but he could not agree with the principle suggested for supporting gasholders. It seemed to him that gasholders would in the future probably be carried up to a much greater height than they had been in the past. He had hoped to have had the finished drawings of the gasholder now being constructed at the South Metropolitan works ready to be shown, but it had not been found possible to get them finished. That gasholder would have three lifts of 53 feet 6 inches each, rising to the height of about 160 feet. Now, a central column would have to be something like 220 feet long, starting from the bottom of the tank, and he confessed that on the calculations he had made as to the possible wind pressure on so large a surface, he would not for one moment think of entrusting the resistance to so small a base as a central column must necessarily have. What he had sought to do was to get as large a base as possible. The base of his column—for it was a column after all—was the whole framing of the gasholder, which was 220 feet in diameter by 160 feet high. It was, in fact, in principle a cylinder outside the gasholder. To all intents and purposes the framing they had been led to adopt at the South Metropolitan works was a braced cylinder. If a wrought-iron cylinder could be erected with a number of ribs for rollers to work upon, that would be what they wanted. They could not do this, but in place of a wrought-iron cylinder they had a series of ribs. The stanchions were 22 inches deep at the bottom and 15 inches at the top, and were merely ribs to receive the strain of the rollers, and were fastened together by 20 diagonal braces. There were 5 tiers of struts in height, and 10 tiers of diagonal bracings starting from the bottom. The object was so to brace the framing together that it was one complete and perfect whole, and he believed it would do without any holding-down bolts at all. The utmost pressure of the wind upon it was about 300 tons, and the weight of the framing was 500 tons, so that the weight alone would be sufficient to resist the action of the wind. Of course they were having holding-down bolts, but only three in number, to each standard. He could not agree with Mr. Barker in his statement that the tank would cost no more on his plan than on the other, for there would certainly be a greatly increased amount of excavation. For instance, in gasholders now-a-days, if the soil would stand during excavation at a steep angle, where clay puddle was not used, but the cone concreted and rendered, an angle of less than 1 to 1 was sufficient. The lower part of the excavation in the tank he was making was 6 inches to 1 foot, so that it left a very large amount of the centre untouched in the ground. This was left in to the original level of the surface of the ground; but under Mr. Barker's plan the greater portion of the core would have to be taken out, and this would add very largely to the expense, and there would be a difficulty in disposing of it. He was quite satisfied that to do so would add many thousand pounds to the expense of constructing the tank. If Mr. Barker could show that by his plan he could get the same safety with diminished cost, gasmen would be very pleased to adopt his principle, but he must confess he did not like the inner side sheeting of the gasholder. It seemed to him it would be "out of sight, out of mind," and would be very apt to be neglected. The cup might lose its water, and nobody know it, and the sheeting might be rusted through from neglect. He was sorry to say so much in disparagement of the idea, but he did feel that the diagonal bracing in conjunction with the outside standards was the most secure form. These diagonals were brought into much greater use when the French system of tangential rollers was adopted. He had combined the English and French systems, each carriage having three rollers, two being tangential, as in France, combined with the usual radial roller; the tangential rollers bearing on the side of the standard threw a direct strain on the diagonal bracing, which being thus placed in tension, there was almost the full tensile strength of the iron to resist the pressure of the roller, which was ample to meet all requirements. The central column, he might say, was not new, for at the South Metropolitan works there were, nearly 50 years ago, some gasholders 40 feet in diameter and 20 feet high, guided entirely by a central cast-iron hollow column about 5 feet in diameter.

Mr. W. R. Cooper (Banbury) said he understood that Mr. Barker's column, when filled with earth, would weigh about 42,000 tons. He should think in localities where the soil was treacherous, there would be great difficulty in getting a foundation for such a column.

Mr. D. Laidlaw (Glasgow) said they had built a large gasholder in St. Petersburg some years ago, with a central pillar. There it had to be inside a building, and the reason it was put up with a central pillar was, so that it could carry the roof of the building as well. It had now worked for 20 years very satisfactorily.

Mr. G. Anderson (London) said he was glad that people were taking to the idea of diagonal braces for gasholders. A few years ago no one thought they looked well enough, but he was pleased that he might have been of some use in drawing attention to this point. He fancied that he must have misunderstood Mr. Barker in stating that he considered there was no use for diagonal bracings. Any man who had been on a scaffolding before the diagonal bracings were put on knew how very shaky the poles were, although the horizontal braces were all right. It was only when the diagonals were put on that the scaffolding was fitted to go up; torsion of the whole was so much easier without diagonal bracing. The main thing in the paper just read, however, was the central column, and theoretically he thought there was a great deal of truth in what Mr. Barker had said. But he did not think they would ever get such a thing properly painted inside. The gasholder did not rise above the column, and unless there were space left for a man to go down, they would never get the thing painted. Anything out of sight like that was very apt to be neglected; there would be a difficulty in the men getting in, and if they did get in, they would not do their work so well as when they could be seen on the outside. The weight of the column, too, was a very important thing. Suppose such a high column actually came into use, the wind pressure would be exercised at the top of it—say, 100 or 200 feet high—which would give it a tremendous leverage, and if it was carried down through the tank, and the tank made round it, there was a great chance as to whether the tank would remain tight with a high wind rocking at the column. Therefore, although it looked beautiful, and had some good points he should not like to adopt it.

Mr. R. Morton (London) said he thought the diagonals of a scaffolding were not quite analogous to the ties in the present case, as they acted both as struts and ties, whilst these were merely ties. This matter had been forced upon his attention lately, but he believed in outside framing, and in a pretty good base to each standard, be it column or upright, of whatever kind. He was not going to cut his bases down as Mr. Livesey had to something like 21 inches by 15 inches, but was keeping them larger. Some of his friends advised him not to put any diagonal ties at all, as they were of no use; they would be valuable if used as struts. But as they were placed on the diagram, if one came into compression the opposite one at the same moment came into tension, and in that way he thought the diagonal bracing was certainly a great improvement. Mr. Livesey's framing would be nothing

at all without diagonal braces, and if it succeeded there, where the standards were simply guides with no base of their own at all, surely, with the addition of diagonal braces, and the columns or standards with larger bases, the structure would be more secure still.

Mr. J. SOMERVILLE (London) said that in the South Metropolitan holder the ribs were tied together by diagonal braces, and they had adopted a peculiar form of roller, having two tangential rollers on the same carriage, and one radial roller. In the 24 columns they had an impact of three-fourths of the circumference instead of one-fourth as usual. The two sides received an impact from the tangential rollers, and consequently the strain was distributed much more evenly.

Mr. BARKER, in reply, said that laying aside the diagonal compression, and treating the top of the standards and the outside framework of the gasholder, they must to some extent look upon part of the section of the framework as acting as a girder sideways, and in that case it would be better to have the girder turned on its side. This was the impression he had formed from looking at the top of it. It all depended upon whether the framework was treated as a solid cylinder, or as merely a tie at the top of the girders. If it was treated as a solid cylinder, then the top girders would be material. If they had a solid cylinder which would turn over by an attack internally at any single point, the stability of the cylinder would be the square of the diameter, but in the case of a solid column filled with sand the stability would be as the cube of the diameter; so that there was a great advantage gained there. As, however, a large base could be obtained round the holder, it was equivalent to weight; a 20 feet column with a 30 feet base would take 250 tons to turn it over. He owned the objection could be brought against a central column that there might be a bad foundation, which would be a difficulty. With regard to the very high column Mr. Livesey referred to, he should tell them that the stability would not decrease with the height. If the column were made twice the height and filled with sand, it would take just the same amount to turn it over as it did now. With reference to Mr. Wyatt's plan, he could only say that he had abandoned the patent for his tank because he found it to be more expensive, but it was not at all similar to his. He had the inner holder inside the annular holder. He placed his framework in the inner ring, and therefore had to build columns in his tank to receive his framework. He (Mr. Barker) did nothing of the kind. Mr. Wyatt had a vertical side all round his inner holder, which caused extra expense, and also the rib of his inner holder, which would cost money, and reduce the capacity of the holders. The whole thing turned on concentration, and the cube of the diameter. With regard to the facility of painting, there would be a space of not less than 3 feet, sufficient to let a man be slung down the central column to examine it at any time and paint it, so that he did not think this disadvantage was worth consideration, and the outside framework, outside the plates, would have a kind of ladder for a man to rest upon while he painted or attended to the inside. With regard to the diagonal bracing, he did not say that it was no good, but it was a source of uncertainty. No authority had laid down any data as to the amount of solidity it would give to the cylinder when attached from the inside. It was a circumstance brought forward in discussion five years ago when Mr. Chance's paper was read; if they could construct a holder which, when attached from the inside, had sufficient sustaining power to turn over as a tube it would be perfection. The amount of earthwork excavated out of the centre of the tank was filled into the column as it was built up, and they need only take sufficient away to fill the column —2000 tons would be sufficient for a 20 feet column, and the hoisting of it would be a matter of very small expense.

The PRESIDENT said they were indebted to Mr. Barker for the able manner in which he had brought under their notice a very important subject. He (the President) apprehended, however, that considerable difficulty would be experienced in getting any one to make a trial, on any considerable scale, of the system of construction advocated by Mr. Barker. There was no doubt that the objections urged against the central column had considerable force, and there was one that occurred to him which had not been mentioned during the discussion, but which it was desirable to bear in mind. With an outside framing there was often considerable difficulty in maintaining gasholders properly level, and they had to be in some instances almost periodically adjusted. He apprehended that, with a central column, this difficulty would be greatly increased, unless a very stiff, and, consequently, expensive inside framing were employed. With regard to the observations made by Mr. Woodall as to the advantages of wrought iron over cast iron, it ought to be remembered that cast iron had borne the test of many years, whereas the introduction of wrought iron was of comparatively recent date. He did not desire to say a word in disparagement of the skilful application of wrought iron for this purpose; but still he would say, "Speak well of the bridge that has carried you safe." Cast iron, it must be remembered, for rigid structures, improved rather than otherwise through age; whereas just the contrary was the case with wrought iron, which would require more than ordinary care to prevent rapid deterioration.

(VI.)
THE DESIRABILITY OF ADOPTING AND PUBLISHING A FORM OF YEARLY STATISTICS OF WORKING RESULTS.

By Mr. G. E. STEVENSON, of Peterborough.

The want of a uniform standard of comparison between the working results obtained by different gas undertakings leads to frequent misunderstanding in regard to the intrinsic value of the results obtained in the management of this or that individual gas-works, and is the source of much fruitless discussion between gas engineers and managers when they meet to talk over the success or failure of the past, and the prospect of improvement in the future. The discrepancies which exist between the results obtained in different gas-works extend to every department over which the manager has control. From the carbonizing to the distribution, and even in the price charged for the gas supplied, the variation is so great as to be unaccountable if the quality and cost of the raw material—viz., the coal carbonized—were to be alone considered.

If we start with the retort-house, we find that the quantity of gas produced from a ton of coal varies from 9000 to 11,000 cubic feet, and it will often be found that the manager and directors of a gas company making 9000 feet to the ton are as satisfied with their results as those who have attained to 11,000 feet. Still, considering the retort-house as the starting-point of gas manufacture, we find that the forms of the retorts used and the number of retorts contained in one setting are as variable as the results produced therefrom, and that in the principle of heating retorts there is no uniformity of opinion or of practice, some engineers advocating direct upward draught, and others preferring a return down draught and underneath flues; while the gas world, in this country at least, appears still undecided as to the advantages to be derived from the use of regenerative furnaces. The dispute as to the proportion of fuel necessary for the adequate heating of retorts is one which continually arises, and which depends for its solution upon the adoption of a uniform retort-setting and furnace, and an approved method of carbonization.

If we turn to the distribution, we find that, although the quantity of gas sold per ton of coal must depend mainly upon the produce in the retort-house, the difference in the proportion of unaccounted-for gas is very considerable, ranging from 5 per cent. to, in some cases, as much as 25 per cent. of the total quantity registered by the station-meter. In respect to this, however, it is very important to notice that the proportion of mileage of the mains to the gas consumed exercises a considerable influence over the percentage of unaccounted-for gas; so that what would be an excessive leakage, demonstrating neglectful management, in some cases, may, in others, be the lowest point to which, with the utmost attention, the manager finds he can reduce the loss.

All this points to the desirability of adopting a more complete form of statistical record, in accordance with which the results of different gas-works may be worked out and published, in order that we may have the means of judging correctly in regard to the value of the working in each individual concern, and be able to arrive in process of time at a more uniform standard of opinion and practice in regard to the forms of carbonizing and other apparatus pertaining to the manufacture of gas. This is the more necessary as the manager of gas-works is often so tied down to his duties, that it is impossible for him to leave his works to visit other places; so that if he be desirous of seeing what is done elsewhere, he cannot always indulge the wish, and often cannot afford to incur the expense of travelling. Very few directors of gas companies have any desire to encourage their manager to make such inquiries. For the most part they are satisfied if his working be not worse than the results of previous years, and prefer to see him located at his office-desk than find him seeking information by visiting other works.

I think, therefore, that the work of providing information as

to working results is one which an Association like this might well take up. I am aware that an attempt to publish some such statement has been made by the Editor of the "Gas and Water Companies Directory," and much credit is due to the author of this effort. At the same time the points upon which information has been published are so few, that no true idea of the condition of the various undertakings, except in regard to their size and extent, can be obtained therefrom. The authority which would attach to statistics if published by the British Association of Gas Managers would give them a greater importance and reliability, and would also, I venture to think, draw forth much information from reluctant quarters, whence, at the present time, no figures can be obtained. I would, therefore, suggest to the Committee of the Association the desirability of adopting a form of statistics, and of forwarding a copy to each member of the Association at the close of the working year, to be filled up by him with the year's results worked out in each particular. The working year should, in my opinion, end with June 30, and not with Dec. 31. The collected results could then be published annually as an appendix to the Report of the Proceedings of the Association, or in separate sheets if preferred.

In the hope that the Committee and the members generally will approve of the suggestion, I have prepared a draft form of statistics embodying, so far as I can see, the information that would be required, the headings of which I will, with your permission, read:—

Name of town. *Population.*

Capital invested in undertaking.

Coal.—Description of coal carbonized; description of cannel carbonized; percentage of cannel; cost price of coal per ton delivered into works; total quantity of coal carbonized.

Gas.—Total quantity of gas produced; gas made per ton of coal carbonized; average illuminating power; average make per mouthpiece per diem; total quantity of gas sold; gas sold per ton of coal carbonized; quantity of gas used on works per cent. of gas made; quantity of gas unaccounted for, per cent. of gas made; cost of manufacturing per 1000 feet produced.

Coke.—Total quantity produced; quantity of coke per ton of coal carbonized; total quantity used for fuel; percentage of coke produced; percentage of coal carbonized; total quantity remaining for sale, per ton of coal carbonized; average price realized per ton of coke sold.

Tar.—Total quantity produced; produced per ton of coal carbonized; average price obtained per ton of tar sold.

Ammoniacal Liquor.—Total quantity produced; produced per ton of coal carbonized; average strength; average price obtained per 1000 gallons sold.

Sulphate of Ammonia.—Total quantity manufactured; quantity made per ton of coal carbonized; cost of manufacturing per ton of sulphate; average price obtained per ton of sulphate sold; amount realized per ton of coal carbonized; total amount realized per ton for residuals.

Retorts.—Description of retorts and settings in use, single or through; number in each setting; method of stoking employed; duration of charges; cost of repairs of retorts and plant per 1000 feet of gas made.

Distribution.—Number of meters in use; price of gas to private consumers; number of public lamps; price of gas to public lamps; percentage of gas consumed in public lighting; mileage of mains in district supplied; consumption of gas per mile of mains; cost of distribution per 1000 feet of gas sold.

Cost of management and all other expenses per 1000 *feet of gas sold.*

Net cost of gas delivered to consumers per 1000 *cubic feet.*

Capital expended per million feet of gas made.

Dividends paid per 1000 *feet of gas sold.*

The publication of statistics such as these, although not quite so complete, is customary in some of the Gas Managers Associations on the Continent, and has, I believe, been productive of very good results, tending to the establishment of a more uniform standard of working than has hitherto obtained amongst ourselves.

For the purpose of comparison, and as evidence of the necessity for such statistics, I have sought to obtain the result of the last year's working from a number of gas-works. With this end in view, a hundred circulars were sent out addressed to the engineers of different works, and containing a statement to be filled up in reference to the working results. Twenty-four of these were returned with the queries more or less fully answered. The list of queries was not so complete as it should have been. I afterwards found that several important items had been omitted in framing the statement. The information received was, however, sufficient to enable me to tabulate the most important elements in the working results of some twenty gas undertakings, and, through the kindness of some friends who forwarded me their half-yearly balance-sheet and accounts, I have obtained the means of comparison in pretty nearly every item appearing on the draft form of statistics.

A simple comparison of the extreme high and low results in the several particulars will be the best evidence of the discrepancies arising between the different statements of working results:—

	Highest.	Lowest.
Cost price of coal per ton	19s. 4½d.	9s. 6d.
Average make of gas per ton . . .	11,160 c. ft.	9400 c. ft.
Average sale of gas per ton. . . .	10,754 c. ft.	8240 c. ft.
Unaccounted-for gas per cent. . . .	16·24	4·00
Cost of carbonizing per 1000 feet .	4·21d.	2·39d.
Fuel per cent. of coke produced . .	51·0	13·6
Tar sold per ton of coal	14 gals.	8 gals.
Liquor produced per ton of coal . .	28 gals. 11 oz.	10 gals. [10–20 oz.
Amount realized by sale of liquor per ton of coal	2s. 4d.	0s. 3d.
Where sulphate is manufactured . .	2s. 3¾d.	10·8d.
Price of gas to private consumers .	4s. 7d.	2s. 1d.
Consumption of gas per mile of mains, cubic feet.	4,720,000	1,356,000
Net cost of gas delivered to consumers	3s.	1s. 7½d.
Capital expended per million feet made	£1984	£416

The results between which these comparisons are drawn are taken from works varying in size from 500 million feet to 10 million feet per annum, and situated in different parts of the kingdom. This fact is sufficient to account for the difference in the price of coal, which we may dismiss with the remark that every gas manager must judge for himself what coal will be most economical for him to use, having regard to the situation and circumstances in which his works are placed.

In regard to the make of gas, the works having the highest make uses coal of the best quality; the cost per ton is, however, not so great as in the case of another gas-works in the same neighbourhood, where the make per ton is much less. The illuminating power also is given as half a candle more in the former than in the latter case. On the other hand, the fuel account is less in the case of the works not making so much gas per ton, although it is also remarkably low in the case of the works making 11,000 feet per ton. In the case of the works which makes an average of 9400 feet per ton, the average quality of the mixed coals used is probably better than the coal used in another works in the same district making 9850 feet per ton. The cost of the coal, too, in the former works is 5s. 6d. more than in the latter; so that, unless there are exceptional circumstances of which the statement received gives no account, here is a clear case for improvement, either in regard to the make per ton or to the price paid for the coals.

Looking now at the fuel account, we find one company using 51 per cent. of the coke produced, and another using 13½ per cent. This method of estimating the proportion of fuel is, however, manifestly unfair. The average quantity of coke produced from a ton of coal varies considerably, according to the description of coal used. The gas-works using 51 per cent. of fuel produces only 1148 lbs. of coke per ton of coal, whereas the works using 13½ per cent. produces 1456 lbs. per ton, and another works where the fuel account is 35 per cent. produces 1498 lbs. of coke per ton of coal. In this latter case the fuel consumed is at the rate of 524 lbs. of coke per ton of coal carbonized, and in the first case, where the fuel account is 51 per cent., the coke used amounts to 585 lbs. per ton, or about 11 per cent. more than the other, whereas the percentage calculated on the produce of coke is nearly half as much again for the latter as for the former works. In continental gas-works, where a decimal system of weights and measures is in use, the percentage of fuel is reckoned on the 100 kilogrammes of coal carbonized, and this gives a much truer idea of the state of the fuel account than the method adopted in this country. I would, however, suggest the method of reckoning the fuel in pounds of coke per ton of coal carbonized, as being the most suitable for our conditions of measurement, and as more actually representing the state of things than any system of percentage can do.

The production of tar we need not dwell upon, this being

dependent more upon the kind of coal employed than upon the process of carbonizing.

Ammoniacal liquor varies exceedingly in quantity and in strength, and this even where the whole of the ammonia is taken out of the gas. At one gas-works, where not a trace of ammonia is ever permitted to pass the outlet of the final scrubber, the quantity of liquor averages 22 gallons to the ton of coal, and the strength is 9 oz.; therefore, $22 \times 9 = 198 \times 17 \div 49 = 68{\cdot}7$ oz. of free ammonia to the ton of coal. At another gas-works the produce averages 28 gallons to the ton, and the strength is 11 oz.; therefore, $28 \times 11 = 308 \times 17 \div 49 = 106{\cdot}8$ oz. of free ammonia. The same class of coal is carbonized at both these works, so that the difference in the resulting quantity of ammonia cannot be due to the different quality of the coal, but must be connected in some way with a difference in the distillation of the coal, and perhaps in the condensation of the gas.

The price obtained for liquor is, for the most part, proportionate to the strength. There are, however, many cases where the liquor is of considerable strength, but small in quantity, and the amount realized per ton of coal is low, pointing to the probability that the whole of the ammonia is not taken out of the gas. One company whose works are unfavourably situated for carriage, realizes the astounding sum of 3d. per ton of coal by the sale of the liquor! This is evidently a case where the manufacture of sulphate of ammonia should be adopted, as the sulphate would cost infinitely less for carriage, in proportion to its value, than the liquor does at present.

In regard to the carbonizing plant, the shape of the retorts and their number in each setting vary considerably; but there is nothing in the results received to give evidence of superiority in any one form of retort-setting. The charges of coal are mostly of six hours duration, some few of four hours, and in one case of five hours. The charging is chiefly done by hand, with the scoop or shovel, some works of considerable size using the shovel. In two works from which results were received, mechanical charging and drawing machinery are in use on different systems, but the best results are to be found amongst those using the shovel.

Taking now the question of unaccounted-for gas and the consumption of gas per mile of main, we find these two are intimately connected one with another. The largest consumption per mile is 4,720,000 feet, and the least is 1,356,000 feet. In the former case the leakage is 8 per cent. of the make, but is equal to 413,000 feet per mile of main. In the latter case the leakage is 11 per cent., but only 150,000 feet per mile. It is therefore evident that the percentage of unaccounted-for gas may be high, and yet the leakage from the mains comparatively small, so that, whenever a statement of the leakage is made, the mileage of mains should be a factor in the calculation.

The price at which gas is sold is governed as much, or more, by the capital invested in the concern, and the dividends or interest to be paid thereon, as by the cost price of the gas itself. In comparing the statements received, the difference between the cost price of the cheapest and the dearest gas supplied is found to be nearly 100 per cent. of the latter, but the difference between the profit derived from the sale of 1000 feet of gas amounts to more than 300 per cent., the lowest dividends which are paid being 9d., and the highest 2s. 5d. per 1000 feet.

Sufficient has, I think, been said to show the desirability of having some more complete and easy method of comparing the working at different gas-works in different parts of the country, and I will now leave the question in your hands for discussion, in the hope that some system such as that suggested in this paper may be found feasible for the Association to adopt.

Discussion.

Mr. Corbet Woodall said the subject now brought forward was a very important one indeed, and, in his opinion, the most important aspect of it was the suggestion that the machinery of the Association might be used to give effect in providing more exact information and data than they at present possessed with reference to a great many subjects connected with gas manufacture. As an illustration, he might mention that the previous night he was in conversation with two gentlemen who had been all their lives intimately connected with gas manufacture, and a question arose as to whether or not the quality of gas which had been stored for a fortnight was materially deteriorated. He felt it was a most extraordinary thing that there should be any difference of opinion, as to so simple a matter, amongst men of such large experience. At the same time, he thought it was hardly desirable to go to the extent Mr. Stevenson had suggested, and to open up the whole details of their working, not simply to one another—to which personally he should not have any objection—but to the world at large, and especially to those whom they must still regard as in some sense the natural enemies of gas companies. Some arrangement might be made, and the reference to the Committee was most desirable, for if they had particulars from many sources upon these doubtful matters of manufacture and procedure available to them, it would be a great help. They had heard a good deal about the advantages of comparison, but he would suggest that any action to be taken should be rather in a set of distinct lines, with a special object in view, than simply the gathering together of a great mass of information, which might be used in an objectionable way. Take, for instance, the statistics suggested with reference to the price of products. One could well understand how useful these might be to certain buyers; on the other hand, they might be useful to those who were obtaining a low price, as indicating what others were doing, and what they might do if they tried, but it would be undesirable to place such materials in the hands of buyers. He would suggest, therefore, that if any reference were made to the Committee it should be with the object of obtaining information on such points as were still in dispute.

Mr. R. Mitchell (Coatbridge) said that in the West of Scotland Association of Gas Managers they had for a considerable time past published such statistics as were suggested in the paper; but there had been a construction put upon the information given which had, to a considerable extent, crippled the usefulness of the publication, and the dread to which Mr. Woodall had referred had in a great degree been realized by the Scotch gas managers. It was always prudent and courteous to one's brother managers to give them information, but when it was printed in public reports there was no saying to what use it might be put; and, therefore, though he would gladly communicate anything to a brother manager, he should refrain from giving detailed information when intended for publication.

Mr. J. Hepworth (Carlisle) said this subject was a very comprehensive one, and he agreed to some extent with Mr. Stevenson that a knowledge of such subjects would be very desirable; but he also agreed with the opinions expressed elsewhere, that some of the results, if they found their way into hands unfavourable to gas companies, might be misused. After all, too, there was great difficulty in getting reliable results of this character. In the West of Scotland Association they found the same difficulty. The gentleman who had just spoken—the late President of that Association—had favoured him with a copy of the report he had referred to, and he (Mr. Hepworth) found, for instance, that in ascertaining the area of the condensers there were such discrepancies as could only arise from a different method of computation being resorted to; and, therefore, if the returns when obtained were published, in order to be useful they must be got out by one person who could overhaul, and go through the whole statistics of the several works. Even then there would be a possibility that the general impression formed might be to some extent inaccurate, and he almost thought there was an instance of this in the paper just read. Mr. Stevenson referred to two places rather near together, and made the remark that the price of coal was very much too high in one place as compared with the other, taking into account the illuminating power. Now, two places might be not very far distant, yet one might be on the top of a coal pit, so to speak, and the other 50 or 60 miles away, in which case the price of coal would probably be exactly double. So when one went to form general conclusions, unless the most minute circumstances were known, one was apt to be misled. He thought with Mr. Woodall that if the matter was taken up by the Committee they might make some valuable suggestions, and he generally agreed with the opinion expressed, that if these returns were got out they should be reserved, if possible, for the sole use of the members, and not published for general use.

Mr. C. Gandon (Sydenham) said there would be great difficulty in obtaining the information suggested by Mr. Stevenson, as was shown by one fact mentioned by himself, that out of 100 circulars he sent out he had only 24 replies, although he said they were not intended for publication, so far as the names of the companies were concerned. If, therefore, it was known that the replies would be published, the difficulty would apply still more. Again, if the particulars were obtained they would not be of much service, unless they could make absolute comparisons of the state of the working

in each case. One manager might be making 10,000 feet of gas per ton out of his coal, and another only 8000 feet, and if they were using a different coal, that was no guide whatever. It would be necessary to get the actual state of affairs in each case, and this they could do very nearly as well themselves by applying to the managers of surrounding gas-works. Thanks to the British Association and similar associations of gas managers, they were all now very willing to impart information to one another; but he could easily understand they would have a great objection to that information being made public.

Mr. W. J. Warner (South Shields) said he quite agreed with Mr. Stevenson that every detail should be worked out to the minutest possible degree; that was to say, every class of labour should be worked out at the cost per 1000 feet, for he always took this as the standard. They sold the gas at so much per 1000 feet, and they should deal with its cost in the same way. The expenditure on every item, too, of material and labour should be worked out under the broad headings of manufacture, distribution, working expenses, and capital. He would do this very minutely, but he would keep it to himself—for his own use. Then, again, he would take broader lines, and would deal with the suggestion somewhat in the manner he shadowed forth at the last meeting of the Association; that was to say, in localities and districts in which there was something in common amongst the works and material. These workings should be averaged, and these averages they would be able to use for the purpose of measuring their own work. In this direction only he thought the Committee could move if Mr. Stevenson's suggestion was adopted. The Committee might prepare forms for managers to work to, by which they could measure their own working, and then they could get something satisfactory to themselves and for those outside. As Mr. Hepworth had observed, there was very much in circumstances to influence workings; for instance, at places in Shropshire and Staffordshire the houses were in blocks, tied together with chains and bands, and every expedient was resorted to for preventing leakage. This was a very different state of things to what occurred in a portion of his own district, in which he had to blast the limestone to lay his mains in. Therefore, it was not possible to compare the working in such places with his own district as far as leakage was concerned; and the same with many other matters.

Mr. George Livesey said there were two questions which arose in relation to this subject—first, was such a scheme practicable? and, secondly, if it were, what would be the use of it? Circumstances varied to so great an extent that the comparison would, he thought, be worthless if returns were obtained—which he doubted would be done. The managers who were working well would be perhaps disposed to send their statistics to show how clever they were, but those who were not working well, or who were placed in adverse circumstances, would be deficient, he was going to say, in common sense if they furnished everybody with the means of finding fault with them. He was afraid also that the statistics—without impugning in any shape the honour of those who sent them—would be hardly reliable. There was a general tendency to exaggerate, even when not intending it, which would probably affect the recorded results. Again, it might do mischief. Far be it from him to say one word against the fullest publicity. In past days, not only with regard to gas, but to most other things, there had been a good deal too much secrecy, and if a brother manager came and asked for information, he ought to have it in the most free and candid manner, without any reserve or hesitation. But if all this information were published, what use would be made of it? It would get into the hands of persons totally incapable of understanding it; and, without saying anything in disparagement of directors, it was not likely that men who came to the works once a week or once a month, for an hour or two, could fully understand the business. They would get hold of certain figures—probably make per ton—and, disregarding all other circumstances, they would say, "So-and-so is making 11,700 feet per ton, you are only making 10,000; how is it?" The 11,700 feet was a real case. It was put to him by a friend, who asked what he thought of it. "They make 11,700 feet per ton, and sell nearly 11,000 feet; 35 per cent. of their coke is made use of for fuel, and the retorts are burnt out in an incredibly short space of time; a very large percentage of rich cannel coal is used, and the gas supplied to the consumer is cut down in quality to the lowest point." He (Mr. Livesey) said he thought it was wrong altogether; they were paying a great deal too dear for their whistle. But directors, and others who did not understand the thing, would say, "Here is 11,700 feet per ton being made at one place, and why cannot it be made at another?" disregarding altogether the other circumstances, which took all the gilt off the gingerbread. Then public bodies, who were not particularly well disposed towards gas companies, would take out those parts which served their purpose, and ignore entirely those which did not. Therefore, while they were much indebted to Mr. Stevenson for bringing the matter forward, and though he was anxious that full information should be given to every one to whom it could be of use, he (Mr. Livesey) thought it would be a great mistake for the Association to undertake anything of the kind proposed.

Mr. J. M'Crae (Bury St. Edmund's) said that he desired to support Mr. Stevenson's suggestion. He had great faith in comparisons, and in these days of opposition, when the gas profession was threatened, to say the least, with an entire collapse, they ought to aim at perfection. It was unattainable, no doubt; but they ought to strive to get as near as possible to it, and this, he took, it was Mr. Stevenson's idea. He (Mr. M'Crae) never could see why there should be any material difference in the results obtained in gas-works, if the capital account was as it ought to be. Some companies were, of course, not in that position, and they went out of the line, and could not be compared with other companies, because of their excess of capital; but there were some companies whose capitals were parallel, and whose results were not parallel, although they were using the same coal. Some gentlemen seemed to think it was inconvenient to have their statistics published, and it might be so in some few cases; but where the gas manager had good results he did not care who knew them. If a manager's results were bad, the sooner he improved them the better; and he thought the Association ought to encourage all attempts of the members to improve themselves. When they could compare results, they knew how they were working, and if they were not so good as others, they should try to improve. He could not agree with all that Mr. Livesey remarked. He said the information, if published, would very likely fall into the hands of persons quite incapable of judging of it; if so, he should not accept their judgment.

Mr. R. O. Paterson (Cheltenham) said he felt somewhat in the position of a culprit in this matter, as he was one of the 100 to whom Mr. Stevenson had sent his papers to be filled up, and he had not done so. He was not ashamed to say it, for while he had no desire to withhold any information from a brother manager, when he knew the purpose to which the information was going to be applied, he felt in this instance he was not justified in giving it. Any statement of working results was valuable and useful, but with all respect to Mr. Stevenson, he (Mr. Paterson) would ask the members what they thought of his criticism on the returns he had obtained. Those statistics put into the hands of a hostile party, instead of into the hands of a friend like Mr. Stevenson, might be made a very powerful weapon for injury. His remarks on ammonia, for instance, were perfectly legitimate and fair from him, but in the hands of an opponent such information as that on which he had based his observations would be dangerous. The object of these statistics was that they might individually obtain such information as would enable them to improve their own working, and the question was, did the information Mr. Stevenson had set forth do this and no more? He thought it went a great deal farther, and if any reference were made to the Committee of the Association it would not be in their power to ask for information to complete the table Mr. Stevenson had prepared. If they wanted to improve their working, the best information they could get was the *net* cost of the manufacture of gas at different places. It was not fair to say one man made 11,000 feet of gas per ton from his coal, and without consideration condemn another who made only 8000 or 9000 feet; the latter might be manufacturing his gas cheaper than the former. If they wanted working results, which were really valuable, they should take three lines simply—first, the *net* cost of gas manufactured, or put into the gasholder; secondly, the net cost of gas distributed, and sent to the consumers meters—that covered all the cost of distribution and of management; and, third, the cost of gas, including dividends and interest. With these three items there was all the information necessary to know whether a particular manager was working as well as his neighbours, or as he ought to do. If they found a manager 20 or 50 miles distant was able to manufacture his gas cheaper, then it would be their duty to inquire the reason; and how could they get the information better than by going to him in a neighbourly manner, and saying, "Here is my result, can you put me in the way of improving my working, and coming up alongside of yourself?" He did not think it would be possible to get satisfactory information by dividing

the country into geographical districts or localities, as Mr. Warner suggested. He knew of an instance where one person was getting his coal 150 miles from the works; and another, 10 miles away, was getting his coal only 50 miles from the works. The one went north, the other south; but they would both be classed as in the same district. The different results obtained in different localities, judged from the point of view of the selling price of gas, were very often due to causes entirely beyond the company's control, and, therefore, if the cost of gas, including all expenses, dividends, and interest, were taken, there might result a calculation under the circumstances unfair to the present working. The proper way was to take the net cost of the gas manufactured, with the expense of distribution, and that was the only fair estimate of the efficiency or non-efficiency of the working.

Mr. H. Woodall (Leeds) said, if it had never been proved before, this discussion had proved that there was "much virtue in an 'if.'" Mr. Stevenson, in dealing with the statistics he himself had obtained, had used the "if" very frequently, and there would be much scope for a shrewd man in manipulating the "if" to the satisfaction of his directors. He (Mr. Woodall) was of opinion that the best field whence a gas manager could obtain useful statistics was the little world that surrounded his own town; but even over the most contracted area there would always be divergence of opinion and experience. For instance, he was himself almost disposed to ignore the question of leakage, being of opinion that it was hardly worth the saving. Again, he was beginning to think that a high yield of gas per ton was an extravagant thing to go in for. In fact, he felt his faith in many of the traditions that had governed the conduct of managers for a long time past to be giving way. With regard to boards of directors, if a return which looked very important was sent in, of course the directors of every company would have access to the sheet, and comparisons would be made, not with the average, but with the best; and managers who did not come up to the best would have their salaries limited until that happy day arrived. Take, for instance, the make of gas per ton. A new man would go on to a works, and hope, of course, to realize a high yield; but probably he would find that his retort-house was built in the wrong place, and all the firing in the world would only produce a great absorption of moisture from the earth, so that it would be perfectly impossible for him under such conditions to realize the desired result. He must pull down his works to obtain better results, and the effect of this would be to enlarge the capital account, and he would be about as badly off at the end as he was at the beginning. Amongst the statistics already given to Mr. Stevenson he noticed that in one instance the price of gas was given at 2s. 1d. per 1000 feet. He was not aware of any place in the kingdom at which gas was being sold at that average price, and if in an item of this sort, coming under Mr. Stevenson's personal supervision, there were such a slip as that, one could easily perceive how very erroneous the statistics might be.

Mr. C. E. Jones (Chesterfield) said that this discussion had been useful in one sense, as it had brought out the qualifications of one of the members, Mr. M'Crae, in advocating a cause which would not bear scientific examination. If Mr. Stevenson desired to obtain the statistics of the working of gas companies, he could do so by applying for a copy of the accounts of every company working under the Gas-Works Clauses Act, 1871, which he could obtain at a shilling a copy. There the information was contained in such a form that it could be made of considerable service in drawing comparisons. But in order that the comparisons should be just there must be a just standard, and where was that standard to be found? The desired information could be obtained, as he had said, from the published accounts of the companies, and it could be applied in a similar manner to that followed by Mr. Field, and any manager getting Mr. Field's book could work out his own results, and have a good standard of comparison in the Metropolitan Gas Companies. It was said that there was a disinclination on the part of directors for managers to visit different places with the object of obtaining information; but, speaking for his own Board, he had never found that spirit manifested. Mr. Livesey, with his usual ability, had pointed out that the man who would not readily afford this information must be working badly; but that cut both ways. He (Mr. Jones) would have been very glad to supply statistical information of his working to any of his brother managers; but he objected to supply it, if it could be used to the detriment of the Company whose servant he was; and to use the machinery of the Association in order to put managers in opposition one to another, was not one of the objects of its founders, and he trusted the proposal put forward would never be sanctioned. They knew very well that when they were before parliamentary committees—and even before their little local parliaments, such as lighting commissioners, town councils, and local boards—the members did not sufficiently understand the question, and made use of such information as was suggested in the paper for purposes which were not always just. On these grounds he was opposed to any scientific tabulation of working results. The rental of companies varied a great deal from circumstances he need not recapitulate, but without knowing all these facts it was possible to do a man an injustice, and say he was working badly, when he might be selling nearly all the gas he was making, and paying a good dividend into the bargain. Again, the commercial aspect of the question had not been touched upon. It was sometimes wise to put up with a positive loss rather than stir up agitation, and be called over the coals; for instance, he remembered one of his friends stating that they supplied gas to the public lamps at a known dead loss, because they wanted to keep well with the public body.

Mr. G. Helps (Bath) said he agreed with many of the previous speakers that it would not be desirable to do as Mr. Stevenson recommended. Some short time ago some information was obtained from his office indirectly, which was used by an *employé* in a neighbouring town, against the gas company, in favour of the corporation of the town; and he had to contradict it. Although he was always very ready to give information to any brother gas manager or secretary, and had always received the same when he applied for it, he did not think it would be desirable to make such particulars as were asked for, public. For many years past he had been in the habit of exchanging copies of his half-yearly reports and accounts with many of his friends; he took care to have them from those on whom he could rely, and the information he obtained in this way was very valuable. He made statistical reports of it, and kept them by him, and if other gentlemen would do the same he thought it would answer the purpose much better than general information which would not be absolutely reliable.

Mr. C. R. Mead (Sutton) said he also agreed that these returns would be dangerous, and he spoke not only as a manager and director of gas-works, but from his experience when a member of a local board. He always instructed his foreman and managers all round not to send returns to anybody, but, when applied to, to send the applicant to him. He was pleased at any time to give information to his brethren, but not to send it broadcast over the country. He would suggest that the members of the Association should send to the Committee copies of their balance-sheets every year, and then, if there was anything worth notice, the Committee could inquire into the matter, and get useful information which would be open to all the members of any gas managers association. This could be done without cost or publicity.

Mr. Stevenson, in reply, said it was not necessary to attempt to answer the various objections made to his suggestions; but he must say that, after having heard all the ideas of many older and more experienced men than himself, he was still of opinion that the more complete the results were the better. He did not think they ought to publish anything which was not as complete as possible, and the more complete such records were, the safer they would be in the hands of anybody. There was considerable force in the objection made as to the possibility of the returns getting into the hands of persons who did not understand the business; but if anything were published, it should be for the benefit and use of the members only. He did think such a step would be a step in advance, as it would give those who were not able at present to produce the best results, and who perhaps had not the opportunity of knowing what results were elsewhere produced, a standard to go by, and set them on inquiry. He was of opinion that some day they would come to public statements of this kind, and he could not help thinking that the objections arose more from a lingering spirit of conservatism than from anything else. The more light they had the clearer things would appear, and the less mistakes would be made. The truth was always the truth, and it was strongest in the end.

Bolton Water-Works Arbitration.—The long-pending arbitration between Mr. P. R. Hoare and the Corporation of Bolton has at length been settled. The matter had been in abeyance for some time, and was resumed on the 8th of March last at the Surveyors Institute, Westminster, before A. S. Hill, Esq., Q.C., when an adjournment took place to suit the convenience of counsel. The question in dispute was as to the value of certain land adjoining the Wayoh and Bradshaw Brooks, in Chapeltown, which had been taken from the representatives of the late Mr. P. R. Hoare, the banker, for the purposes of the Corporation Water-Works. After a litigation extending over several years, the parties have now agreed to an award by the Corporation of £6000, without costs on either side.

Parliamentary Intelligence.

HOUSE OF LORDS.

THURSDAY, JUNE 17.

LOCAL GOVERNMENT (GAS) PROVISIONAL ORDER BILL.—This Bill, brought from the Commons, was read the first time, and referred to the Examiners.

HOUSE OF COMMONS.

TUESDAY, JUNE 15.

LOCAL GOVERNMENT (GAS) PROVISIONAL ORDER BILL.—This Bill was reported without amendment: Provisional Order confirmed.

HYDRANTS IN THE METROPOLIS.—Sir Henry Selwin-Ibbetson gave notice that, on Tuesday, July 13, he will call attention to the report of the Metropolitan Fire Brigade Committee of 1877; and move—"That, in the opinion of this House, a greater amount of protection to life and property in the Metropolis would be attained by the transfer of the Fire Brigade to the Metropolitan Police, and by the establishment of hydrants on constantly charged mains throughout the Metropolis."

THE SEWAGE OF THE LOWER THAMES VALLEY.

Mr. CUBITT asked the President of the Local Government Board whether he had arrived at any decision respecting the sewage scheme of the Lower Thames Valley Main Sewerage Board; and whether he would lay upon the table the official reports of the Inspectors upon it.

Mr. DODSON: The Department has recently received the report of the Inspector, which has been referred back to him for some further information. The matter will receive my attention as early as practicable, but the question is one of unusual importance, and involving interests of great magnitude, and it cannot be disposed of without the most careful consideration. When a decision has been arrived at, I will see whether the report can be laid on the table; but it is not usual to do so, as these reports are intended for the guidance of the Board only. If the report is laid on the table, a similar course must be adopted with the evidence, which extended over more than 40 days.

WEDNESDAY, JUNE 16.

LOCAL GOVERNMENT (GAS) PROVISIONAL ORDER BILL.—This Bill was read the third time, and passed.

THURSDAY, JUNE 17.

GAS AND WATER ORDERS CONFIRMATION BILL.—This Bill was reported from the Select Committee: Provisional Orders confirmed.

FRIDAY, JUNE 18.

GAS AND WATER ORDERS CONFIRMATION BILL—This Bill was read the third time, and passed.

Miscellaneous News.

METROPOLIS WATER SUPPLY.

The Registrar-General publishes the following table in reference to the water supply of London during May. According to the returns furnished to him by the Metropolitan Water Companies, 145,745,332 gallons, or 662,188 cubic mètres of water (equal to about as many *tuns* by measure, *tons* by weight), were supplied daily; or 250 gallons (113·6 decalitres), rather more than a *ton* by weight, to each house, and 35·2 gallons (16·0 decalitres) to each person, against 33·3 gallons during May, 1879.

COMPANIES.	Number of Houses, &c., supplied in May, 1879.	May, 1880.	Aver. Daily Supply of Water in Gallons* during May, 1879.	May, 1880.
Total supply	560,466	582,505	132,584,518	145,745,332
From Thames	265,860	279,750	68,303,106	74,614,416
„ Lea and other Sources	294,606	302,755	64,281,412	71,130,916
THAMES.				
Chelsea	29,700	30,071	8,480,200	9,108,100
West Middlesex	52,145	54,327	10,752,634	11,722,142
Southwark and Vauxhall	83,263	89,879	23,910,463	23,955,758
Grand Junction	39,648	41,352	12,101,909	13,554,816
Lambeth	61,104	64,121	13,057,900	16,273,600
LEA AND OTHER SOURCES.				
New River	128,099	130,373	27,065,000	29,703,000
East London	118,910	122,746	29,136,000	32,285,800
Kent	47,597	49,636	8,080,412	9,142,116

* Including that for manufactures and for various purposes other than for domestic consumption.

Note.—The return for May, 1880, as compared with that for the corresponding month of 1879, shows an increase of 22,039 houses, and of 13,160,814 gallons of water supplied daily.

NEW GAS-WORKS FOR NEWBURY.

It will be remembered that for some time past the Newbury Town Council have had under consideration the question of extending their gas-works, or of erecting others of more suitable capacity for meeting the growing requirements of the town. The matter having been referred to the Gas Manager (Mr. J. G. O'Farrell), and that gentleman reporting to the effect that any extension of the existing works would at best be but a temporary remedy, the Council resolved, at their meeting on Feb. 20, [see *ante*, p. 328] that enlarged works should be erected on a site near the Great Western Railway, as originally proposed by the Gas Committee, the plans for the same to be prepared by, and the work to be carried out under the direction of Mr. O'Farrell. Acting on these instructions, the works were commenced, and such progress has been made that the concrete foundation for the new gasholder has been satisfactorily completed. The holder itself will be capable of containing 90,500 cubic feet of gas, and as regards size will present a striking contrast to the small holders now in use. The buildings will be of a substantial and suitable character, and will include a retort-house, with six benches of 7 retorts in each, adjoining which will be the coal stores, capable of holding 600 tons. A great saving in the matter of cartage will be effected by the construction of a siding, running from the goods yard of the Great Western Railway into the stores. The plans also embrace station-meter, engine, boiler, exhauster, and purifying houses, &c. The contracts will, it is hoped, be completed within four months, in order that the inhabitants may have the advantage of a full and efficient supply of gas by the time the winter has set in. Pipes are already being laid from the old works to the new site.

The laying of the foundation stone of the main block of buildings took place on Saturday, the 5th inst., the ceremony being performed by the MAYOR (J. B. Stone, Esq.), in the presence of Alderman J. P. Jackson, Chairman of the Gas Committee, and other gentlemen. The stone is fixed at the north-east corner of the building, and bears on its front the following inscription:—"This stone was laid by James Benjamin Stone, Mayor of Newbury, June 5, 1880.—Alderman Jackson, Chairman of the Gas Committee." An inscription on the east side runs as follows:—"H. Burke Godwin, Town Clerk; Joseph Gough O'Farrell, Engineer and Manager."

The company having assembled on a platform erected near the stone,

Mr. O'FARRELL said, in the absence of the contractor, it became his pleasing duty to hand a trowel to the Mayor, and request him to lay the foundation stone of the gas-works, and thus inaugurate an undertaking of the highest possible importance to the borough.

The MAYOR said he accepted the trowel with much pleasure, and he expressed a hope that the work to be inaugurated that day would be carried out satisfactorily, and that the undertaking might be completed without the occurrence of any accident to life or limb.

Alderman JACKSON said that, as Chairman of the Gas Committee, he had had a good deal to do with this matter, and he had every reason to be thankful that he had been successful in securing the removal of the gas-works to the new site. He had no doubt the undertaking would prove to be a source of profit, and a benefit to the town generally. It was to him a matter of great gratification to see the new works commenced, and he sincerely hoped that no untoward event would happen during their progress.

Alderman HICKMAN observed that, as one of the oldest inhabitants of Newbury, he felt much pleasure in attending, especially as he witnessed the laying of the foundation stone of the old gas-works in 1825. He was glad to be at the inauguration of the new works, which had been called into existence by an increase of population and a greater amount of prosperity in the borough, which he hoped would continue.

The stone having been lowered, and the level applied, the MAYOR declared that the stone had been properly laid.

Votes of thanks were then presented to the Mayor, to Alderman Jackson, and also to Mr. O'Farrell, the latter of whom replied, remarking that it had been his ambition to see the works erected on the present site. He felt certain the undertaking would prove of advantage financially.

PRESENTATION OF A TESTIMONIAL TO MR. EDWARD HORNER.

The testimonial resolved upon at the last meeting of the Phœnix Gas Company was presented to Mr. Horner, at the old board-room, 70, Bankside, on Tuesday last. Most of the late Board, and representatives from the Shareholders and Officers, were present.

Mr. SHUTER, as the oldest friend, on behalf of the subscribers, stated that although all most readily acknowledged the great value Mr. Horner's services had been to the Company, yet the offering they had met together to beg of their late esteemed Chairman to accept, was made not by way of compensating that gentleman for those services, but as a personal pledge of affection in respect to past associations, and as an earnest of all good wishes for his future health and happiness.

Mr. HORNER, replying, thanked Mr. Shuter and all his friends, present and absent, for their kind expressions and good wishes. The beautiful gift he had received would be handed down, he trusted, to his children with pride, as a memento of the affection which it had that day been his lot to enjoy.

The present consisted of a set of four very chaste classical figures in silver, each bearing a fruit dish. They were designed by the celebrated sculptor Monti, whose "Veiled Nun" was the object of so much interest in the Exhibition of 1851; and were furnished by Messrs. Hancocks, of Bond Street. The cost was £220—just the sum received.

At the close of the meeting a very general feeling of admiration was expressed at the excellent manner in which all the arrangements had been carried out by Mr. I. A. Crookenden, the Honorary Secretary.

MR. T. O. PATERSON, of the Rochdale Corporation Gas-Works, has received the appointment, recently advertised in the JOURNAL, of Gas Engineer to the Corporation of Birkenhead. We understand that there was a large number of applications for the post; among those selected besides Mr. Paterson being Mr. J. M'Gilchrist, of Dumbarton; Mr. T. B. Ball, of New Wortley; and Mr. H. Hill, of Liverpool.

CHESHAM GAS AND COKE COMPANY, LIMITED.—This Company was originally constituted by provisional registration on July 1, 1846, and completely registered on Aug. 17, 1847. On Oct. 25, 1856, it was incorporated under the 1856 Act, and, in accordance with a resolution passed at a general meeting of Shareholders held on the 28th ult., was on the 2nd inst. incorporated as a limited company, under the Acts of 1862 and 1879. The nominal capital is £5850, in 290 £10 shares (all of which are allotted and fully paid up), 290 £5 shares, and 600 £2 10s. shares.

THE STOCKTON AND MIDDLESBROUGH CORPORATIONS WATER SUPPLY.—One of the Provisional Orders Confirmation Bills now before Parliament contains the Order granted by the Local Government Board "to amend, vary, and partially repeal the Stockton and Middlesbrough Corporations Water-Works Act, 1876," and several petitions have been lodged against it. The *Northern Echo*, writing on the subject, says: "Apart altogether from the special grounds of petition and complaint, affecting private estate or corporate public rights, which will, no doubt, come in due course before a Committee of the Commons for consideration, the important question is raised by these petitions, whether the Local Government Board have not far exceeded the authority conferred upon them by Parliament by making a Provisional Order for the important purpose of abstracting water from a river, extending the period for exercising compulsory powers of taking land and other property, and dispensing with all the notices to parties affected which would be necessary in the ordinary and invariable rule and practice of Parliament. It is alleged that in this particular instance, after an inquiry extending over 40 days, Parliament in the year 1876 made what was intended to be a final settlement of the questions affecting the water supply of the Tees towns and the abstraction of water from the River Tees. It is stated that all the parties interested in the river were then heard. It is further alleged that the present Provisional Order is the result of a perfunctory and insufficient investigation of *ex parte* statements by an Inspector, whose report is quite *ex parte* in its character; and it is held to be completely *ultra vires* of their powers for the Local Government Board, on any such report, to presume to make an Order repealing the former settled enactment of both Houses of Parliament. One of the petitioners, we learn, is Mr. John Bowes, of Streatlam, who was a strong supporter of the Corporations of Stockton and Middlesbrough in 1875 and 1876. Another is the Darlington Corporation—whose opposition is probably put forth with a view of securing checks on over-pumping from their own source of supply. There is also a petition from Egglestone against postponing the execution of the new works in that neighbourhood. But, in the meantime, the principal point of public interest likely to be raised is that mentioned above, which aims at the legality of the Provisional Order itself."

London: Printed by WALTER KING (at the office of Clayton & Co., 17, Bouverie Street, Fleet Street), and published by him at No. 11, Bolt Court, Fleet Street, in the City of London.—Tuesday, June 22, 1880.